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WESTERN GULF DRAINAGE BASIN. A COOPERATIVE STATE-FEDERAL REPORT ON WATER POLLUTION

Public Health Service
Dallas, Texas

1951

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Water Pollution Series, No. 8

For Clean Water—"One River, One Plan"

Western Gulf DRAINAGE BASIN

A COOPERATIVE STATE-FEDERAL REPORT ON WATER POLLUTION

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FEDERAL SECURITY AGENCY

Public Health Service

82

SUMMARY REPORT ON WATER POLLUTION

Western Gulf Drainage Basin

Prepared by

FEDERAL SECURITY AGENCY
Public Health Service
Division of Water Pollution Control
Western Gulf and Colorado River Drainage Basins Office

1951

In cooperation with:

Colorado State Department of Health
Louisiana Stream Control Commission
New Mexico Department of Public Health
Texas State Department of Health

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INTRODUCTION

The Federal Water Pollution Control Act, Public Law 845, passed by the 80th Congress in June of 1948, requires the Surgeon General of the Public Health Service to cooperate with other Federal agencies, with State and interstate water pollution control agencies, and with municipalities and industries in the preparation or adoption of comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof, and improving the sanitary condition of surface and underground waters.

In developing these programs, due regard must be given to improvements necessary to conserve the Nation's waters for public water supplies, propagation of fish and aquatic life, recreational purposes , agricultural, industrial, and other legitimate uses.

Recognizing the fact that full technical information was not available to permit the development of such comprehensive programs immediately for most of the Nation's waters, the Public Health Service envisioned the development of these programs in two general phases. The first phase contemplated the development of a series of reports, consistent with presently available data, which would: provide a reference point for measuring progress; provide a guide to needed additional data; provide a basis for the logical development of comprehensive programs; provide a basis for approval of loans to States, interstate agencies and municipalities at such time as the Congress made available funds for this purpose; and serve to inform the public on the problem of water pollution and set forth suggestions for pollution control.

The collection of available data as of July 1, 1950, has been completed under the first phase of the program. Such data have been assembled with the cooperation of State and interstate water pollution control agencies. Through these agencies additional data have been obtained from other State officials, county and city officials and representatives of industry. Federal agencies also have been of great assistance. In order to make this information available at the earliest possible moment, these data are being presented in 15 summary-type reports covering the United States by major drainage basins. This report on the Western Gulf Basin is one of that series.

These summary reports present information about the ways our water resources are used, the pollution going into our water resources and the resulting damages, the benefits which may result from pollution prevention and abatement, the pollution prevention measures now in effect, and those required.

They are prepared in two parts. Part one considers the water pollution problems of the basin as a whole. Part two presents briefly the data for each of the several sub-basins of the major basin, including a list of projects now known to be needed for water pollution control.

Since the summary reports are based on data which are now readily available, these reports do not discuss or evaluate the most advantageous water uses as they are related to pollution control. Such considerations will be included as a part of the comprehensive water pollution control programs.

The deficiencies in data and the gaps in information indicated in these summary reports are as significant as the presentation of available facts and statistics. They indicate the work which still needs to be accomplished by water pollution control authorities for the preparation of comprehensive programs.

Data and knowledge now available are sufficient, however, to permit the immediate solution of many of the pollution problems within the Western Gulf Basin without awaiting the results of additional surveys and studies. The tabulations of pollution abatement projects which are included in Part Two of this summary report represent presently known needs. However, future studies and evaluations may result in some changes in the estimations of requirements.

A sincere effort has been made by all who contributed to this report to present a fair picture of the complex water pollution problems in the Western Gulf Basin and to present reasonable conclusions and recommendations. It is our hope that this report, as a step in the cooperative development of an ultimate comprehensive pollution control program, will help in safeguarding the water resources of the Western Gulf Basin.

Leonard A. Scheele

Surgeon General

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ACKNOWLEDGMENTS

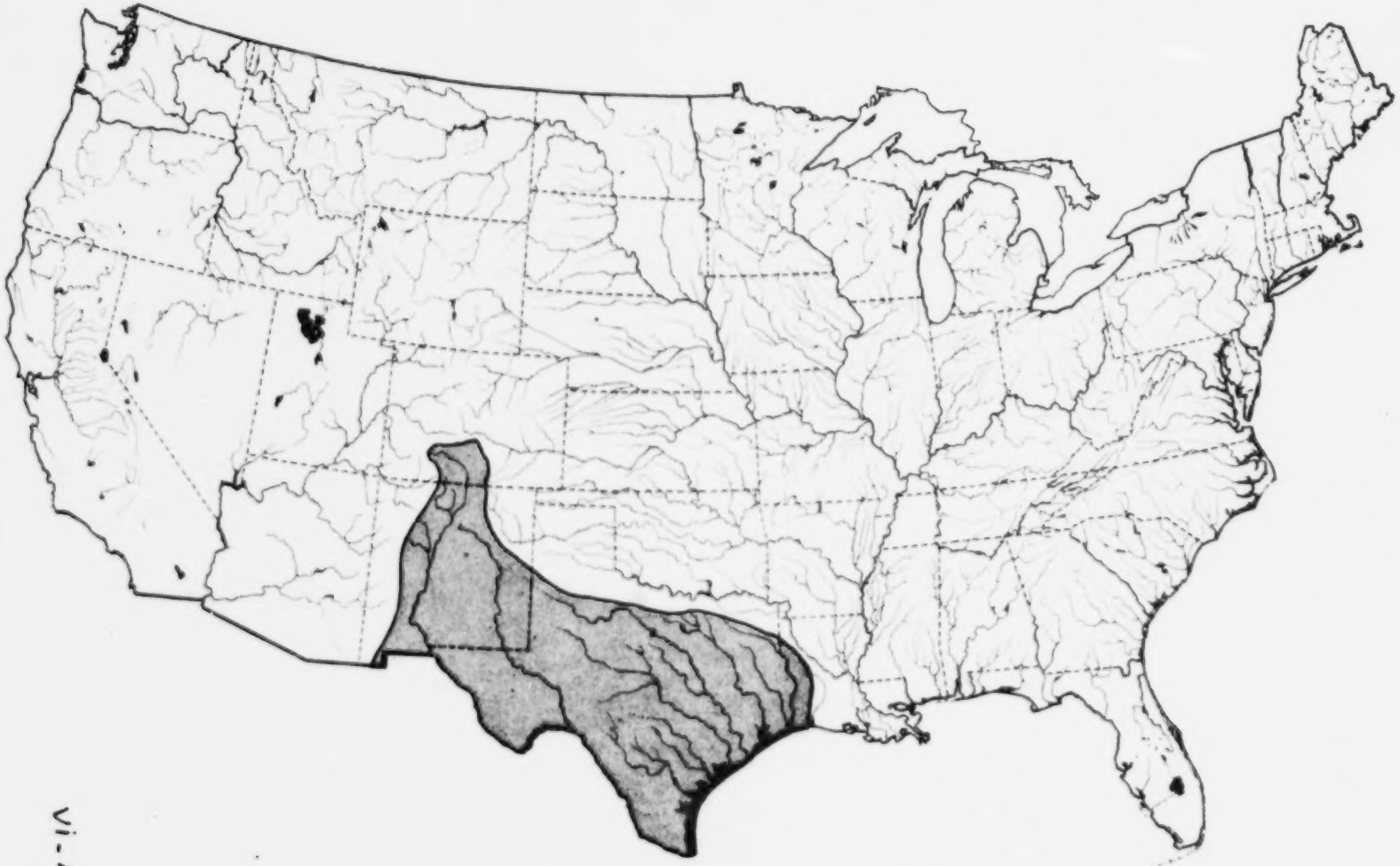
The Public Health Service wishes to acknowledge the full cooperation received in the preparation of this report from the following: the Colorado State Department of Health, the Louisiana Stream Control Commission, the New Mexico Department of Game and Fish, the New Mexico Department of Public Health, the Texas State Department of Health, the Texas Board of Water Engineers, and the Texas Game, Fish and Oyster Commission.

Federal agencies from which assistance was obtained include the Corps of Engineers, Department of the Army; the Fish and Wildlife Service, Geological Survey, Bureau of Reclamation, and the National Park Service, Department of the Interior; the Soil Conservation Service, Department of Agriculture, and the International Boundary and Water Commission, United States and Mexico.

Finally, there is acknowledged the assistance of other State agencies and individuals interested in water resources development and conservation, who have contributed information through other sources than those listed above.

LOCATION MAP

Western Gulf Drainage Basin



VI-A

SUMMARY

The Western Gulf Drainage Basin embraces about one tenth the area of the United States. It includes major portions of Texas and New Mexico and small parts of Louisiana and Colorado. Approximately 80,000 square miles of the basin lie within the Republic of Mexico and are therefore beyond the scope of this report.

More than six million people reside in the basin. Two-thirds of these live in cities and towns and the other third live on farms and ranches.

Land and water are the most valuable natural resources of the basin, but, at present, mineral resources have the spotlight. Sixty percent of the proven oil reserves of the continental United States are located within the basin. Tremendous industrial expansion is following the rapid development of these oil reserves. The basic economy of the basin has developed around agriculture but industrial development is rapidly changing the picture. The future will probably see this area as one of the country's most important industrial centers.

The waters of the Western Gulf Drainage Basin are used for municipal and industrial purposes, agriculture, and to a lesser degree for recreation and for the disposal of municipal and industrial wastes. Irrigation is, by far, the major use of waters from both surface and underground sources.

Although the heavy silt burden carried by the rivers of the basin in itself restricts extensive recreational usage, there are a few localized areas--Galveston Bay in particular--where recreational use is reported as definitely impaired by poor water quality.

Agriculture, industry and urban development would be seriously handicapped without the rivers of the basin. The economic development of the basin, first agricultural and now both agricultural and industrial, has progressed in direct relationship to the development of river water storage and distribution works.

Heavy silt pollution occurs in all of the sub-basins. It interferes with water use by siltation of reservoirs, aggradation of irrigation works and siltation of ship channels and harbors. Silt from the Colorado River is reported to have all but destroyed 6 to 7 thousand acres of oyster reefs around Matagorda. The Soil Conservation Service estimates that a possible reduction of approximately 50 percent of the silt load in the streams by complete conservation programs throughout the basin is possible. Justification of the cost of such programs from the standpoint of silt pollution abatement has not been clearly determined. However, silt pollution abatement is only a small portion of the benefits of such programs. The retention of valuable top soil on the farms where it can produce crops is the major benefit. It is estimated that a reduction of only 20 percent of the harbor and channel siltation will result in an annual savings of $1,000,000 for maintenance dredging.

Except for silt there are no specific types of pollution that affect the entire basin but there are many areas where specific types of pollution are acute. Heavy pollution reaches tide water in the vicinity of Sabine Lake and Galveston Bay. Pollution is also becoming a problem in the inland areas near Dallas, Fort Worth, San Antonio, El Paso and the extreme Lower Rio Grande. Most of the cities involved are considering corrective action. Throughout the rest of the basin stream pollution is generally scattered and localized in small areas directly below points where domestic sewage or industrial wastes enter the stream. State agencies reported 221 instances where short reaches of streams were considered unsatisfactory from a nuisance or pollution standpoint. High chloride content has been reported to have, in the past, adversely affected the public water supply of Temple and Gonzales, Tex. and rice irrigation water in the vicinity of Beaumont, Tex.

The State water pollution agencies consider that existing State legislation is adequate to eliminate or correct present and future water pollution. Texas is considering certain amendments to strengthen and broaden existing statutes under which its present program is operating.

Three sub-basins are interstate to the extent that stream flows and pollution originating in one State may affect the water use in another State. The Sabine River Sub-Basin, in the extreme eastern part of the basin, has its headwater area in Texas where its river picks up considerable organic and inorganic pollution. The river forms the boundary between Texas and Louisiana for 180 miles and receives pollution from both States. As its waters are used in both States any pollution originating in one State may affect water use in that State or in its neighbor State. The extreme western sub-basin, the Upper Rio Grande, starts in Colorado, crosses New Mexico and continues through Texas. Some trouble has been experienced at the municipal water plant at El Paso, Tex., because of industrial waste pollution believed to have originated in New Mexico. A study of this situation is underway and correction is anticipated in the near future. The upper half of the Pecos River Sub-Basin lies in New Mexico and the lower half in Texas. At present no interstate pollution problems have developed in this sub-basin. There are expanding oil and potash industries in the Pecos River Sub-Basin and almost the entire river flow is used for irrigation in both States. As natural salt pollution of the Pecos River has limited the beneficial uses of the water, a brine pollution

problem can possibly develop in the future. Two other sub-basins, the Brazos and Colorado, have their upper areas in New Mexico with the bulk of the sub-basins in Texas. The New Mexico portion of these sub-basins is arid and water flows from New Mexico into Texas only in extremely rare instances.

The two Rio Grande sub-basins are international in character, as the Rio Grande forms the International Boundary for 1,300 miles. Water is taken from the river for use in both the United States and Mexico, so any pollution originating in one country may affect the water use in the other. Problems arising from such instances are handled by the International Boundary and Water Commission.

Reported damages from man-made pollution in the basin are largely confined to areas of maximum population and industrial concentration. These affected areas contain more than half of the people residing in the basin, and are the most logical locations for further industrial and urban expansion.

Table A shows that on July 1, 1950 there were 485 municipalities in the basin with public sewerage systems serving over 4,000,000 people or two-thirds of the basin population. As shown in Table C, all but 35 of these municipalities had one or more sewage treatment plants. The 474 treatment plants served approximately 94 percent of the sewered population. The sewage from over 60 percent of the basin's inhabitants received some degree of treatment in municipal sewage treatment plants. The total municipal waste load reaching the streams had an estimated population equivalent of one and a half million people.

As indicated in Table E, approximately half of the existing sewage treatment facilities were unsatisfactory and needed correction.

As shown by the large number of existing treatment plants, the Western Gulf Drainage Basin is well advanced in domestic sewage collection and treatment. However, many of the existing plants were constructed some years ago and are now structurally unsound or lack adequate capacity to handle the increased loads imposed on them by the phenomenal population growth of the area. This has resulted in the need for a large amount of plant reconditioning and construction before satisfactory pollution abatement can be realized. As shown in the tables a large planning and construction program to alleviate these needs is now underway.

The industrial waste pollution picture is far from complete for the Western Gulf Drainage Basin. Table B indicates that many industrial plants and oil wells may be discharging wastes to the streams. As there are about 1,000 industries and over 100,000 oil wells operating in the basin, it is readily apparent that the task of obtaining detailed data regarding wastes and disposal methods is enormous. Obviously it is impossible to collect pollution data for each of the 100,000 operating oil wells and accordingly such investigations have been and will continue to be confined to areas where pollution is known to have occurred and where potential problems exist. The State water pollution control agencies are continuing the collection of industrial wastes pollution data as rapidly as their resources permit.

Oil producing and processing industries predominate as shown by Table D. Industries processing farm and forest products closely follow. The latter are dispersed throughout the areas of the basin where only meager industrial information is available and few appear in the tables of this report.

The limited information on industrial waste treatment facilities permitted the determination of adequacy of existing waste treatment for only thirteen plants in the entire basin, 11 of which were considered satisfactory.

State pollution control agencies considered operation as unsatisfactory at 207 sewage treatment plants and satisfactory at only 185. Information was not available on the operation of 82 other plants. Until such time as operation is satisfactory at all plants the full value of the capital investment will not be realized.

The State pollution control agencies have been handicapped by lack of personnel and funds. Federal aid for pollution control activities now enables them to spend more time on pollution abatement activities. The State agencies hope to contact all plants within the next year and assist the municipalities in bringing operation to desired levels.

The State pollution control agencies of the basin are very active in correcting pollution caused by municipal sewage. As shown in Table F, five sewage treatment plants were constructed in 1946, 21 in 1947, 26 in 1948 and 47 in 1949. In these four years sewage treatment facilities were provided for approximately one million people by 99 municipalities. On July 1, 1950 there were 54 municipalities constructing treatment facilities to serve another million people. In addition, final plans were approved for 25 additional municipal sewage treatment plants while 32 other municipalities were preparing plans. There are no data readily available concerning the number of industrial waste treatment facilities constructed since World War II.

Estimates of July 1, 1950 indicated that the construction of the facilities which the State pollution control agencies considered necessary to correct municipal sewage pollution in the Western Gulf Drainage Basin would cost $56,344,000. Table C shows a breakdown of these requirements and indicates a need for 43 new sewage treatment plants, additional facilities at 118 plants and the replacement of 94. While many industrial plants discharge wastes to watercourses and 61 are known to have treatment facilities, it was not possible to determine if treatment or additional facilities are needed. Due to the large number of industries in the basin and the complexity of industrial wastes treatment it is impossible to estimate the cost of abating industrial waste pollution at this time.

CONCLUSIONS

1. A large portion of the basin is semi-arid and agriculture is dependent upon surface and underground waters to supplement rainfall.

2. The major uses of waters in the Western Gulf Drainage Basin are for irrigation and domestic and industrial water supply.

3. The future economic development of the Western Gulf Drainage Basin will depend, in large measure, on the availability of water of suitable quality.

4. Extreme variations of flows of the streams of the basin require a high degree of treatment of all wastes discharged to the watercourse to protect the quality of water. Zero flows are not uncommon on some major streams.

5. Additional basic information on industrial waste pollution and on water uses will be needed in furthering pollution abatement activities in some areas.

6. In some areas information on the self-purification characteristics of the streams, the extent of water damage during critical periods, and the degree of treatment required to produce the quality of water suitable for the desired uses might be needed.

7. The major water damages from man-made pollution are confined to two tidewater and five inland areas. These are in the vicinity of Sabine Lake, Galveston Bay, and near Dallas, Fort Worth, San Antonio, El Paso, and the extreme Lower Rio Grande.

8. Pollution effects from industrial and municipal wastes are, in general, confined to localized areas immediately below or adjacent to waste outlets to streams and tidal waters.

9. Producing oil wells contribute large quantities of brine pollution to the waters of the basin, and control and abatement of this pollution is the major problem in many areas of the basin.

10. Other industries, principally the processing of petroleum and farm products, contribute pollution in Western Gulf Drainage Basin through the discharge of large volumes of untreated and partially treated wastes.

11. Data on industrial wastes are limited, but in eight of the ten sub-basins water quality is affected by such wastes.

12. Two thirds of the basin population is served by public sewerage systems. Approximately 94 percent of these are also served by sewage treatment plants.

13. On July 1, 1950 sewage pollution was contributed to the basin waters by 212 communities that have inadequate or obsolete sewage treatment plants. There are 35 other communities that do not have sewage treatment facilities, many of which do not have sewers at present.

14. Heavy silt pollution from natural sources occurs in all of the sub-basins and interferes with water use by siltation of reservoirs, aggradation of irrigation works and siltation of ship channels and harbors.

15. Soil conservation programs are well advanced in many parts of the basin but existing silt pollution indicates a need for such programs on a much wider scale.

16. Pollution from natural mineral salts restricts use of the waters of the Salt Fork of the Brazos to power generation and the agricultural use of the waters of the Pecos River to irrigation of salt resistant crops.

17. A large number of municipalities and industries need new or additional treatment facilities and improved operation and maintenance to protect water quality for present and future uses.

18. One hundred and eleven municipalities were actively engaged on July 1, 1950 in preparing plans and constructing sewage treatment plants for the correction of pollution from domestic sewage.

19. The control agencies concerned with water pollution prevention and abatement in the Western Gulf Drainage Basin need additional technical personnel and funds to continue to plan and carry out pollution abatement programs.

RECOMMENDATIONS

It is recommended that:

1. The present programs for water pollution control be continued and intensified so that the highest use can be made of the water resources.

2. A comprehensive program for water pollution control be developed throughout the basin so that the most beneficial uses can be made of the water resources.

3. Basic information on industrial waste pollution and water use be obtained where required in order to expedite development of comprehensive water pollution control programs.

4. The extent of pollution damage occurring during critical periods and the resulting effects on beneficial water uses be determined so that the degree of treatment required for the desired water quality can be established where necessary.

5. Where changes in existing State water pollution control legislation may be necessary to enable the State agencies to strengthen their program, such legislation should be enacted.

6. All groups and individuals having an interest in water use and pollution control cooperate with the State water pollution control agencies in developing and carrying out informational programs for presenting the importance of water pollution control to the public.

7. The State legislatures provide the State water pollution control agencies with sufficient funds to enable them to increase technical staffs, expedite development and carrying out of a comprehensive water pollution control program, develop informational programs for the public and for industry, and promote community planning of pollution abatement measures.

8. State water pollution control agencies expand their cooperative programs for improving sewage and waste treatment plant operation and maintenance.

9. Soil conservation programs be expanded in order to keep valuable top soil on the land and reduce silt pollution of the watercourses.

GENERAL DESCRIPTION

Historical Background

Historically, all of the Western Gulf Drainage Basin was Indian country and inhabited by many tribes ranging in culture from the Karankawas of the Texas coastline -- a cruel cannibalistic group of nomads existing upon a primitive seafood economy -- to the Pueblos of New Mexico who developed a drama, religion, and system of government so advanced that they could be called savages only because they had no written language.

The first white men to penetrate beyond the Gulf coastline were Cabeza de Vaca and his companions who left Galveston Island in 1536 and only four of whom many years later reached the Pacific coast after one of the most amazing journeys in the annals of man. A series of expeditions were undertaken shortly thereafter by the Spanish Conquistadores who were stimulated by the Mexican riches plundered by Cortes and the persistent stories of the mythical, but fabulously wealthy, "Seven Cities of Cibola" and the "Gran Quivira". Out of these expeditions came no gold but eventual Spanish colonization leading, in 1609, to the establishment of Santa Fe, now the second oldest permanent European community in the United States. Following this development, all Spanish colonization was directed towards the upper Rio Grande valley until the Frenchman, La Salle, appeared on the Texas coast and established Fort St. Louis at the head of Lavaca Bay as a staging point for expeditions inland. The French venture came to naught following the murder of LaSalle in 1687, but it did serve to divert attention of the Spaniards eastward to the area that is now Texas.

Several missions, which became focal points about which colonization developed, were established in east Texas during the late 1600's. Eventually, in 1718, San Antonio became the halfway post on the Camino Real which connected the east Texas missions with the presidios of northern Mexico. The colonization of Texas by white men then proceeded rapidly--with a series of events as dramatic and colorful as are to be found in American history. Eventually, the Anglo-American colonists from the North proclaimed the independence of Texas. Stirred by the heroic, if futile, defense of the Alamo at San Antonio, this independence was won through a crushing defeat of Santa Anna's Mexican army in the Battle of San Jacinto, April 21, 1836. Although San Jacinto was fought over the local issue of Texas independence, nevertheless, it eventually led to the accession of most of the present Rocky Mountain and Pacific Coast areas by the United States. The Republic of Texas, proclaimed with the victory at San Jacinto, was officially annexed to the United States on December 29, 1845.

Little fighting occurred in the area during the Civil War because of its isolated location. An expedition of Texans captured Santa Fe -- New Mexico having remained with the Union-- but this thrust was short lived owing to the early appearance of Union troops in superior numbers. Aside from the Santa Fe expedition, military action was confined to border and coastal skirmishes attending efforts to break the blockade running of cotton. The last battle of the Civil War was fought near Brownsville, Tex., some three weeks after Lee's surrender at Appomattox. Like the other States of the Confederacy, Texas following the Civil War underwent an era of reconstruction by Northern carpetbaggers which was accompanied by all the political and economic disorder common to that period. Texas was readmitted to the Union in 1870 and, for the first time since the coming of the white man, no cloud of armed conflict hung over the area. With stability came the dawn of economic and industrial expansion.

Physical Description

The Western Gulf Drainage Basin includes those streams that originate east of the Continental Divide and south and west of the Mississippi watershed. Some 80,000 square miles of the basin lie in the Republic of Mexico and, therefore, beyond the scope of this report. The area of the Western Gulf Drainage Basin reported herein totals over 298,000 square miles, of which about one fourth is confined within non-water contributing desiccating basins and one half is in country so arid that even the major streams are intermittent in character. The Western Gulf Drainage Basin includes major areas of Texas and New Mexico and small parts of Louisiana and Colorado.

The topography of the Western Gulf Drainage Basin ranges from the broad Coastal Plain at sea level to the 14,000-foot peaks of south-central Colorado. Both the Rio Grande and the Pecos rise as high mountain streams and flow generally southward across the broad high plateaus of central New Mexico. They are separated by the mountain ranges that enclose

the desiccating Tularosa basin. At the New Mexico-Texas border, the Rio Grande swings eastward to form the International Boundary for 1,300 miles to the Gulf of Mexico. East of the Pecos River lies another broad flat desiccating basin that merges into the Great Plains of West Texas. Drainage of the Great Plains, which forms the upper Brazos and Colorado Rivers, is towards the east over the Cap Rock Escarpment to the North Central Plains of Texas. The North Central Plains dip gradually eastward and form the headwaters of the Trinity, Sabine, and Neches Rivers. The southern portion of the North Central Plains terminates in the Edwards Plateau, one of the largest spring-fed areas of the United States from which flow the southern tributaries of the Colorado and the many streams which form the Guadalupe and Neuces Rivers. All drainage from the central plains breaks to the southward as it traverses the broad and flat Gulf Coastal Plains.

The rivers in their aggregate comprise the Western Gulf Drainage Basin, and their mean annual runoff in acre-feet are as follows: Sabine, 6,934,000; Neches, 5,737,000; Trinity, 8,199,600; Brazos, 6,174,000; Colorado of Texas, 2,457,000; Guadalupe, 1,848,700; Nueces, 663,000; and the Rio Grande (exclusive of Mexico) with its principal American tributary, the Pecos, 5,019,000. Of these nine rivers, only the Rio Grande, the Pecos, and the Sabine are interstate streams, as the permanently-flowing waters of the remaining six are confined within the State of Texas. All of these rivers, excluding the Pecos, empty directly into the Gulf of Mexico.

Rainfall over the Western Gulf Drainage Basin varies widely with normal annual means ranging between 52 inches in the extreme southeastern section to 8 inches in the arid plains of New Mexico. Generally, the rainfall is heavy in the mountainous headwaters, light across the plains of New Mexico and West Texas, and increases rapidly eastward towards the Gulf of Mexico. The annual rainfall is erratic, depending largely upon the frequency and intensity of localized summer thunderstorms and the appearance of occasional tropical hurricanes moving inland from the Gulf. A precipitation of 20 inches within 3 hours and 30 inches in 48 hours has been recorded accompanying Gulf hurricanes. One storm was estimated to have precipitated 8.9 inches of rain over an area of 66,000 square miles.

Air temperatures likewise vary over wide limits. The mean annual temperatures range between 40° F. in the mountainous headwaters to 70° F. in south Texas. Mean annual maximum temperatures over the basin are 85° F. in the higher sections of Colorado, about 100° F. over most of New Mexico, and 105° F. over virtually all of Texas except the Gulf Coast which is about 5° F. less. The mean annual minimum temperatures are -30° F. in the headwaters, -5° F. to 10° F. over New Mexico, and rise progressively eastward over Texas to 25° F. along the Gulf Coast.

Native vegetation, as might be expected, is as varied as the topography and the climate. In a general manner, the vegetation pattern tends to parallel the rainfall. Over those areas receiving the heavier precipitation, such as the high mountains and the Pine and Post Oak Belts of eastern Texas, forests predominate. Bordering the timbered areas, the vegetation changes to the coarse grasses and with the decreasing rainfall to the prairie grasses. The semi-arid plains of West Texas and eastern New Mexico largely are covered with thin stands of buffalo and mesquite grasses and low, drought resistant scrub oaks and mesquites. Generally, the vegetation of the arid sections is confined to greasewood, snakeweed, and various species of cacti.

Considering the tremendous range of physiographic and climatic conditions over the Western Gulf Drainage Basin, it is not surprising that strikingly different river characteristics are found in different portions of the basin and, in the case of the longer rivers, even between the upper, middle, and lower courses of the same stream.

The Neches, Sabine, Trinity, and the lower reaches of the Brazos and Colorado are relatively comparable streams. All traverse similar terrain and all are sluggish, turbid, meandering rivers subject to sudden flooding and slow recession during periods of heavy precipitation. Great erosion accompanies the rains and these streams annually carry about 60 million tons of soil to the Gulf.

The upper Brazos and upper Colorado and their widely diverging tributaries drain the semi-arid bunch grass prairie land and the desert of the North Central and Great Plains regions of Texas. These streams are intermittent in character and, in many cases, carry extremely high dissolved salt and/or silt burdens from natural sources.

The spring-fed Guadalupe and the Nueces, on the other hand, are clear clean streams and quite unlike either the larger streams to the eastward or the upper Brazos and Colorado.

The Rio Grande and the Pecos are clear mountain streams near their respective origins, but both rapidly assume the characteristics and the heavy silt burdens of desert rivers upon entering the plateaus of central New Mexico. The Rio Grande occasionally has no flow immediately above Elephant Butte Reservoir in southern New Mexico and the flow of the Pecos is intermittent over several reaches immediately below storage reservoirs. The lower Pecos likewise acquires a very heavy dissolved solids burden from natural sources. The Rio

Grande acquires a heavy silt load through New Mexico, estimated at 37 million tons annually, all of which is deposited in the stream bed or in Elephant Butte Reservoir. A second silt burden, estimated at 15 million tons annually, is acquired over the 1,300 mile reach between El Paso and the Gulf of Mexico.

Economic Development

The area covered by the Western Gulf Drainage Basin has been, and still remains, predominately agricultural. Cattle ranching over the vast open range became the first major industry of the area. Lack of surface water for stock, plus difficulties in confining and shipping cattle except by the expensive and inefficient--yet colorful--roundup and cattle drives to market, severely handicapped cattle production until the invention of barbed wire, the American type of windmill and the coming of the railroads to the plains near the close of the nineteenth century. The tremendous surge in beef cattle production that quickly followed these developments led to the large meat packing centers in Fort Worth, San Antonio, and Houston and the many smaller establishments spread throughout Texas and New Mexico.

Concurrent with the great expansion in the cattle industry came the discovery of petroleum at the turn of the century. In 1901, Spindletop near Houston, Tex., startled the world with magnificent gushers and gave the area its first really great oil field. The discovery of Spindletop, and the rapid succession of other oil discoveries in both Texas and New Mexico which have continued up to the present time, gave the area--and Texas in particular--tremendous local capital as well as the fuel and raw materials for the great manufacturing industries of today. Sixty percent of the proven oil reserves of the United States are located within the basin.

A comparatively recent development has been made in potash mining and refining in the Lower Pecos River area of New Mexico near Carlsbad. Large expansions are underway in this industry.

At the present time, manufacturing in the basin is principally concentrated in the Dallas-Fort Worth and the Houston-Galveston sections of the Trinity River watershed. Lesser centers are found in the Lake Sabine area at the mouth of the Sabine and Neches Rivers, near the mouth and in the El Paso sections of th Rio Grande, around Waco on the Brazos River, and San Antonio on the San Antonio River.

Another noteworthy development that has contributed much towards the economy of the basin has been the recent expansion of irrigation, using both surface and underground water sources. Although certain portions of the basin received sufficient rainfall to support longstanding large-scale agriculture--the cotton farms of the Blacklands in eastern Texas being the outstanding example--it is irrigation water that constitutes the very life blood of agriculture within the basin. The Pueblo Indians of New Mexico, completely dependent upon irrigation for their food crops, established the prototype of small private irrigation systems which have been constructed over the years principally for rice cultivation along the Texas coastline and for grain, fruit, and vegetable crops generally throughout the basin in locales where adequate irrigation water supplies could easily be developed.

The great expansion in irrigation, which underlies crop production as a major industry of the basin, stemmed from the more recent development of the immense underground water resources in the Great Plains of eastern New Mexico and West Texas and from the construction of huge water storage reservoirs. The combined storage capacity of the surface water reservoirs now operating in the Western Gulf Drainage Basin is over ten million acre-feet. The reservoirs currently under construction will hold an additional nine million acre-feet, and other reservoirs authorized for construction will add over nine million more acre-feet of storage capacity. Within the near future a total water storage capacity of nearly 30 million acre-feet will have been provided within the basin. This represents a long step in the direction of complete control over all surface waters of the basin to the end that all legitimate uses of water will be equitably served to their mutual and maximum benefit.

USES OF WATER RESOURCES

The waters of the Western Gulf Drainage Basin are used for municipal and industrial purposes, agriculture, and--in lesser degree --for recreation and municipal and industrial waste disposal. Irrigation is, by far, the major use of waters from both surface and underground sources. The use of the waters for waste disposal is minor, being confined to the dilution of some stored oil field brines which are released during periods of high stream discharge. The recreational use of waters of the basin is minor except for the headwaters of the Guadalupe, Rio Grande, and Pecos; the "Highland Lake" region of the Colorado; the Gulf Coast area; and the impoundments, where such use is exceedingly important.

Throughout the entire basin, a total of 605 communities, with a combined population served estimated at approximately 4,000,000, utilize water from surface and/or ground sources. Of these, 116 communities with over 1,300,000 inhabitants are served with approximately 15 million gallons of surface water per day, 450 communities supply about 1,900,000 inhabitants with 243.5 million gallons per day of ground water, and 10 communities serve approximately 600,000 inhabitants with 46 million gallons per day from combination ground and surface sources No data on municipal water use are available for 203 communities utilizing ground water, 25 communities using surface water, and one community with a combination source. The per capita consumption averages 112 gallons per day in those communities for which municipal water use data are available.

Data on the industrial uses of water in the basin are incomplete except for the Sabine, Neches, and Trinity Rivers. In addition to many large combination grants for both municipal and industrial uses, water rights for miscellaneous industrial purposes have been granted on these rivers to the extent of over 1,000,000 acre-feet annually.

Irrigation has been developed along the Gulf Coastal Plain where surface waters from the Sabine, Neches, Trinity, Brazos, and Colorado Rivers are used on over 500,000 acres (1948) to supplement, in approximately equal quantities, water from underground sources. Irrigation is widespread in virtually every location west of the line of 30-inch annual rainfall in central Texas where the terrain and available water sources will permit. During 1939, a total of over 1,500,000 acres were under irrigation in the Rio Grande watershed. That same year, the remaining watersheds in the Western Gulf Drainage Basin had approximately 1,000,000 acres under irrigation.

More recent basin-wide irrigation data are not available, but it can be assumed that the acreage under irrigation has increased materially during the past decade. For example, during 1948, in Texas alone a total of approximately 2,750,000 acres were being irrigated--1,250,000 with water from surface sources, 1,475,000 with water from underground sources, and 25,000 with water from both surface and underground sources.

Data on the total quantity of water used for irrigation throughout the basin are not available but, except in the rice growing areas of the Gulf Coastal Plain, water rights to two acre-feet per surface acre ordinarily are allocated. Generally speaking, the largest areas under irrigation from surface water sources are found along the Rio Grande and in the Gulf Coastal Plain.

Surface waters of the Western Gulf Drainage Basin are used for the disposal of the large quantities of salt water brought to the surface with the pumping of crude oil. Although pollution control agencies generally recommend reinjection of oil field brines into deep subterranean strata, nevertheless there are many cases where this method is not being utilized. In some instances, the salt water wastes are often lagooned during dry periods for release when river discharges are sufficiently high to avoid damage to the downstream water users.

Some fishing and migratory bird hunting is done along the rivers of the Western Gulf Drainage Basin. The impoundments of the basin, of which there are now over one hundred exceeding one thousand acre-feet in capacity, receive very heavy recreational use. Lake Texoma, 25 miles outside the Western Gulf Drainage Basin, is used to illustrate the heavy recreational pressure upon impoundments in this area because it is the only one for which data are available. Lake Texoma in 1948 attracted 2,397,000 pleasure seekers--more than did the Yellowstone, Grand Canyon, and Yosemite National Parks combined.

The marine fisheries of Texas are influenced to a greater or lesser degree by the rivers emptying into the Gulf of Mexico. These fisheries are of consid-

erable economic importance locally while the extensive shrimp fishery is of national importance as well.

The heavy silt burden carried by most rivers of the basin in itself restricts full recreational usage.

POLLUTION CONTRIBUTED TO WATER RESOURCES

The waters of the basin receive immense quantities of pollution from natural sources in the form of silt and mineral salts and large volumes of pollution resulting from the activities of man. The source of natural pollution is, unfortunately, in the headwater areas of the basin and its effects are felt throughout the entire basin. Man-made pollution is distributed over a wide area of the basin and with notable exceptions is discharged into the waters in such quantities that it can be assimilated by the larger volumes of the receiving waters without adversely affecting them over extensive stretches, although there were 221 locations where local stream conditions were unsatisfactory or of a local nuisance nature. With the exception of the Trinity and San Antonio Rivers, which have populous industrial centers near their headwaters, the major rivers of the basin are relatively free of the effects of man-made pollution until they enter the Gulf coast area where the greatest portion of the basin's industry is concentrated.

Many of the streams in the arid region of the basin are heavily laden with mineral salts leached from the alkaline soils of the area. Two rivers in particular have a dissolved mineral content that impairs their waters for many uses. The Salt Fork of the Brazos River is so highly mineralized that its waters are reported to be unfit for any use except power production, even after dilution with an equal volume of sweet water from the other main tributary of the Brazos River. The Pecos River carries a dissolved solids pollution load, received from natural sources, estimated to average 1.6 million tons annually at the mouth of the river.

The loose, unstable soil of the arid portion of the basin is subject to serious erosion and the silt pollution of all rivers draining the area is tremendous. In the non-arid portions of the basin, overgrazing of pasture land and poor farming practices have resulted in increased erosion and heavy silt pollution of streams. The streams in only two of the river basins, the Guadalupe and Nueces, are relatively free from damaging silt pollution. The Sabine, Neches, Trinity, Brazos and Colorado Rivers are reported to carry 60 million tons of silt to the Gulf annually. The Rio Grande picks up a silt load of 37 million tons annually while passing through New Mexico. This is deposited before the waters leave Elephant Butte Reservoir but a second silt burden of 15 million tons annually is picked up below the reservoir and carried to the Gulf.

Pollution from municipal sewage is scattered throughout the basin and is of concern to health authorities. The extent of this pollution is illustrated by the fact that the condition of the receiving streams immediately below 221 municipalities was considered unsatisfactory and at 178 of these locations nuisance conditions were reported to exist.

All but 35 (several of these communities have sewers and plants under construction) of the 485 sewered communities shown in Table A have sewage treatment facilities and sewage from only 260,000 persons, about 6.5 percent of the total sewered population was being discharged on July 1, 1950 into the surface waters of the basin without some degree of treatment. Most of this untreated sewage is discharged into tide-water.

Many of the existing sewage treatment plants are in need of enlargement or replacement if adequate treatment is to be secured. The operation of 20 percent of the plants was reported to be unsatisfactory, in many cases due to inadequate capacity of the plants.

Because of the overloaded or antiquated condition of many of the plants it was assumed for purposes of estimation that the primary treatment plants would remove 25 percent of the pollution material and the secondary treatment plants 75 percent. Using these values it is estimated that the waters of the basin are receiving a sewage pollution load equivalent to the untreated sewage from 1,500,000 people.

Industrial waste pollution is wide spread throughout the basin but, with the exception of that caused by brine wastes from oil wells, is of minor importance, except in localized areas which for the most part are on tidewater. Considerable amounts of industrial waste reach tidewater in the vicinity of Sabine Lake and Galveston Bay where petroleum refining and chemical manufacturing plants are concentrated. Other major industrial areas where industrial waste pollution is becoming a problem are the inland manufacturing centers near Dallas, Fort Worth, San Antonio, El Paso and the extreme lower Rio Grande. Food processing wastes, including those from meat packing, constitute a major portion of the industrial wastes in these inland areas. Oil refineries and plants processing farm products are scattered throughout the basin but, except in those areas mentioned above, the plants are relatively small and the pollutional effects are localized and generally confined to the receiving tributary streams.

Table A. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	--	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	485	4,155,496	Not applicable
Total	485	4,155,496	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Note: The total amount of municipal pollution reaching the watercourses is estimated to have a population equivalent of 1,500,000.

The principal industries in the basin which produce waste inimical to downstream water uses include 115 refineries, 190 dairy products plants, 100 meat packing and allied plants, 200 food processing plants, and 175 chemical plants. In addition there are numerous textile mills, 7 breweries, 7 wineries, some tanneries and 3 pulp and paper mills in the basin.

Table B includes all of the 196 industries and 2,313 oil wells for which any specific waste information was available. This covers only a very small portion of the industrial waste picture of the basin, since about 1,000 industries and over 100,000 oil wells are known to be operating in the basin. The large number of these makes it impossible to secure detailed data on the amount of pollution and the extent of the resulting stream damage from these sources except for those cases where pollution damages have occurred or threaten to occur.

Table B. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	90**	Undetermined
Producing inorganic wastes	2,374***	Not applicable
Producing wastes of undetermined type	78	Undetermined
Total	2,509+	--

*Industries having separate outlets and discharging wastes directly to watercourse.

**Includes 33 plants also producing inorganic wastes.

***Includes 2,313 individual oil wells.

+Total adjusted to correct for duplication noted in footnote marked thus**

Note: Approximately 1,000 industries and 100,000 oil wells are operating in the basin. Except for those industries listed in the above table no pollution data are available at this time.

The lack of more specific information can be attributed to the fact that as far as now known and except for oil well brine wastes, industrial wastes are causing only localized damage to the waters of the basin. Most of such damage occurs in tidewater areas. The limited personnel and funds of the State water pollution control agencies have been used on the more urgent problems of municipal sewage pollution abatement.

As stated above there are over 100,000 producing oil wells operating in the basin. These wells are the source of large volumes of salt brine wastes and are considered, by the Texas State pollution control agency, to be the major potential pollution problem, with the exception of municipal sewage. The amount of brine produced cannot be estimated from the oil production or from the number of operating wells, as the volume and strength of the waste brine varies from field to field and from well to well in the same field.

Data on oil field wastes have been secured for cases where public water supplies and other water uses have been damaged or threatened with damage from brine pollution. These data can not be used to evaluate the overall problem, since no basin-wide study of the problem has been made.

The problem is a growing one and demands constant attention if the waters of the basin are to be adequately protected.

The lower portion of the Neches River Sub-Basin is the only area where sufficient data are available to estimate the potential industrial waste pollution load. By use of production data it is estimated that the wastes discharged by the manufacturing plants in this area have a population equivalent of 649,000. However, most of these wastes receive some treatment before entering tidewater but the extent of this treatment is unknown and the actual amount of pollution reaching the waters has not been determined.

DAMAGES TO WATER RESOURCES FROM POLLUTION

Damages to the waters of the basin are, for the most part, limited to localized areas and within these areas have only a minor effect on present water uses. The one notable exception is the Salt Fork of the Brazos River which has a natural mineral content so high that its waters are unfit for any use except the generation of power. The lower Pecos river is also heavily polluted by natural salts and its agricultural use is restricted to irrigation of salt resistant crops.

The heavy silt burden carried by most of the streams of the basin makes the waters too turbid to attract wildlife or to support those species of fish desired by anglers. Deep mud deposits on the banks and bottoms of the streams make them unattractive and reduce their recreational use and value. The removal of silt deposits from ship channels is one of the major expense items in maintaining the many ports of the basin and the intercoastal canal

Siltation is progressively reducing the storage capacity of all of the reservoirs in the basin. Some reservoirs are so seriously threatened by siltation the people dependent upon them have sought other sources of water, an expensive and difficult undertaking in this arid region.

Lake Corpus Christi, an impoundment in the Nueces River, has, within 16 years, lost 35 percent of its original storage capacity. Each year 12 million tons of silt settle in the quiet waters of the Elephant Butte Reservoir located on the Rio Grande. In the Pecos River Sub-Basin the Lakes McMillan and Avalon have lost much of their original capacity to silt. The Possum Kingdom Reservoir on the Brazos River is losing 7,000 acre-feet of storage capacity each year by siltation. Over six million tons, about 4,100 acre-feet, of silt is being deposited each year in Lake Buchanan on the Colorado River.

Silt from the Colorado River is reported to have all but destroyed six to seven thousand acres of oyster reefs around Matagorda. The heavy silt load of the waters materially increases the maintenance costs of the numerous irrigation systems of the basin.

Damages from pollution by municipal sewage are scattered throughout the basin but, in general, are confined to short portions of localized small streams immediately below sewer outlets. Pollution control agencies report stream conditions as unsatisfactory below 221 municipalities. At 178 of these locations the conditions were considered to be of such a nature that a nuisance had developed immediately below the point where the sewage entered the tributary stream. The principal rivers of the basin, with the exception of the San Antonio and Trinity Rivers, are practically free of damage by sewage pollution. Waters in Galveston County are reported to be damaged by pollution from municipal sewage.

Fishing, waterfowl habitat and trapping have been seriously affected on the West Fork of the Trinity River for 30 miles below Fort Worth. The value of fish and wildlife is reported to have been seriously damaged on the Trinity River for 100 miles below Dallas. In the past water was released from storage reservoirs above Fort Worth and Dallas at irregular intervals for the purpose of clearing the Trinity River of sewage deposits. This resulted in what is locally known as "black rises", which were reported to create a possible health menace, kill fish, and cause other nuisances from Fort Worth to the Gulf. The fishing in Buffalo Bayou has been seriously affected by sewage pollution and Galveston Bay is so seriously polluted that the Texas State Health Department prohibits the sale of all Galveston Bay oysters for food. On the Bosque River, fishing activity has been reduced by sewage pollution for 15 miles below Stephenville. Fish and wildlife have been seriously affected on a 10 mile stretch of the Media River and are reported to be seriously affected on 150 miles of the San Antonio River below San Antonio. In most of these instances corrective action is being taken.

Industrial wastes are reported as causing damages at times. Oil field brine wastes are alleged to have damaged rice fields in the lower Sabine and Neches River Basins in the past. Disposal methods put into operation since that time are considered adequate to prevent damages in the future. Refinery wastes are reported to have seriously impaired fish life and habitat in the vicinity of Beaumont. The reported damages on the Trinity and San Antonio Rivers and in Galveston Bay, while specifically attributed to domestic sewage, is probably increased by the presence of industrial wastes. The operation of shell dredges and other dredges is reported to have destroyed oyster beds in the coastal waters of the Gulf of Mexico from Copano Bay to Galveston Bay, a distance of about 200 miles. Galveston Bay fisheries production has been reduced from over a million pounds in 1890 to a mere 336 pounds in 1948. Pollution from domestic sewage, industrial waste and silt are thought to be the major factors responsible

for this almost complete destruction of the fisheries industry.

Salt brine wastes from oil fields in the upper drainage area of the Leon River have repeatedly threatened the public water supply of Temple, Tex., and the water supply of Gonzales, Tex., located on the Guadalupe River, was threatened by oil field wastes from the Luling area. El Paso, Tex. reports an increased cost for water treatment for the removal of tastes and odors caused by industrial waste. But corrective measures were to be initiated through the cooperation of industry concerned.

Caustic soda in the wastes of an industrial plant near Freeport, Tex. is reported to have caused periodic fish losses in the coastal waters of the Gulf. The use of the playa lakes (wet weather lakes) as slush pits by oil companies is reported to have caused loss of waterfowl. Plating wastes are reported to have caused fish kills in the Guadalupe River Sub-Basin near San Antonio.

It has been observed that brine holding pits not only ruin soil for future agricultural development, but when abandoned remain a source of pollution due to constant leaching of deposited mineral salts during rains.

Reported damages from man-made pollution in the basin are largely confined to areas of maximum population and industrial concentration. These affected areas contain more than half of the people residing in the basin, and are the most logical locations for further industrial and urban expansion.

BENEFITS RESULTING FROM POLLUTION PREVENTION AND ABATEMENT

There are many benefits to be derived from a pollution prevention and abatement program in the basin. In addition to the obvious benefits that can be realized by the correction of pollution conditions now causing known damages, there is the benefit projected into the future of having clean water immediately available for any water use which may develop. Industry needs large volumes of good water and the opportunity of securing industrial development in an area is enhanced by the presence of this water. The community that can offer an ample supply of good quality water has a decided advantage over the community that has only polluted water available.

There is a real benefit to the public health through the treatment of domestic sewage by reducing the chances of water-borne disease infection. Sewage polluted waters are always a threat to the public health.

The public health significance of sewage pollution in irrigation waters has not been definitely established and health benefits resulting from pollution prevention of the irrigation waters are difficult to define. The practice of irrigating truck crops with sewage contaminated water is not desirable. The value of truck crops in Texas for 1948 was $49,713,000 and more than half of this was derived from crops grown in the lower Rio Grande Valley where irrigation is practiced. If pollution of irrigation waters should cause the loss of market for these crops, it would result in a tremendous economic loss to this valley. The cost of maintaining adequate sewage treatment facilities for the 157,000 residents of the Valley served by sewerage systems is indeed a good investment if it protects the truck farming industry from the stigma of using sewage polluted irrigation water.

Many of the workers in the irrigation fields use the canals and streams as sources of drinking water. Pollution prevention practices will lessen their chances of contracting water-borne diseases and spreading them to others.

Surface waters now used as public water supplies in the basin are readily treated to produce safe potable water. However, salt brine pollution from oil wells is a constant threat to many supplies because, once in the water, it cannot be removed. Activities of the water pollution control agencies have proven effective in abating critical brine pollution conditions and restored affected waters to a satisfactory quality.

Most of the surface water used for rice irrigation originates in or passes through oil fields where brine wastes are produced and the proper disposal of the brines to prevent pollution of the irrigation water is essential. The protection of the rice crop, which had a farm value of $56,000,000 in 1948, is one of the benefits of pollution control.

The removal of industrial wastes from the river at El Paso will result in a direct saving in water treatment costs and in improved water quality.

Elimination of pollution from the waters in the Beaumont area will do much towards restoring fish and aquatic life. Pollution abatement to remove nuisance conditions would be justified by the increased value of the recreational facilities in this populous area.

Pollution has virtually wiped out the fishing industry in Galveston Bay which at one time produced over a million pounds of fish annually. The restoration of this industry by pollution abatement will add much to the economy of the area. In addition, proper pollution control will again make it possible for the bay to produce oysters that are safe for human consumption and another valuable source of employment and revenue will be restored to the area.

Continued pollution of the waters of Galveston Bay may impair its use for recreational purposes. Restoration of clean waters to the area might bring increased recreational use. By having clean water nearby local communities will not only benefit from greater opportunities to participate in outdoor recreation, but will realize a considerable savings in travel as well. The entertainment and service business which would develop at these recreation centers would furnish employment and bring additional revenue to the area.

The nuisances reported below so many of the communities will be eliminated by pollution abatement and increased property value along the streams will result.

There are areas along some streams of the basin where bathing and recreation were once enjoyed, but pollution of the waters has discouraged their continued use. Pollution abatement will again bring these areas into active use and enable many people to enjoy recreation without the expense and inconvenience of traveling long distances to find clean waters.

Ground water supplies are being rapidly depleted in places and many communities are

faced with the need of supplementing these supplies with surface water. Such communities would benefit by having a suitable surface water source readily available.

In some instances industry pollution abatement practices may result in greater utilization of raw materials and recovery of valuable by-products. Adequate waste treatment may enable industry to re-use the water now going to waste and, in an area where water is so vital, this would be of great economic importance.

Reduction of a large portion of the silt burden of the rivers will reduce maintenance cost of river channels and irrigation works. It will also improve recreational facilities and have a beneficial effect on aquatic life.

The maintenance of adequate canal, harbor and ship channel depths along the Texas Coast requires periodic dredging which costs about $5,000,000 annually when a full program of maintenance is undertaken. The cost of removing silt deposits carried down to the shipping areas each year by the rivers and adjacent connecting streams cannot be separated from the cost of removing that brought into ship channels from existing deposits through the action of currents, waves and tides. The heavy silt burden of these rivers and streams leads to the conclusion that much of the ship channel siltation is caused by annual deposition from adjacent connecting streams. Soil conservation practices in the farm areas of the basins can do much towards reducing the silt load of the rivers. If only 20 percent of harbor and channel siltation can be eliminated, the monetary savings will amount to about $1,000,000 annually. Other benefits to be derived from soil conservation practices would be reduced interference with water-borne shipping because of reduced dredging time and, most valuable of all, the retention of irreplaceable top soil and fertility on the fields where it can serve the farmers and the nation.

POLLUTION PREVENTION MEASURES IN EFFECT

The State water pollution control agencies consider their present laws adequate to correct any cause of pollution. A brief discussion of these laws follows:

Louisiana

In 1948 Louisiana adopted a comprehensive State Water Pollution Control Act with authority vested in a Stream Control Commission. The State Board of Health also has certain water pollution control functions relating to public health.

The Stream Control Commission has been given the power and duty of administering all laws relating to the pollution of any waters of the State. The Surgeon General has designated it as the State Water Pollution Agency pursuant to the Federal Water Pollution Control Act. The Commission has control of waste disposal, public or private, by any person, into any of the waters of the State or any tributaries or drains flowing into such waters, for the prevention of pollution thereof tending to destroy fish life, or to be injurious to the public health, the public welfare, or to other aquatic life or wild or domestic animals or fowls.

There are no exemptions from operation of the Act except as to powers of the State Board of Health in regard to matters directly affecting the public health.

New Mexico

The State of New Mexico places the water pollution control program in the State Department of Public Health. In addition, the Department of Game and Fish, the State Engineer, the Interstate Stream Commission, the Oil Conservation Commission, and the Plumbing Administrative Board all have statutes, regulations or codes that involve control of water pollution. New Mexico does not have a separate water pollution control act directed to the prevention, abatement, and control of pollution of the waters of the State in the light of all legitimate uses of such waters. However the broad and comprehensive coverage by statutes and regulations of the Department of Public Health, and the controls by other State agencies have proven to be adequate. The State Engineer, is given general supervision of the waters of the State and the measurement, appropriation and distribution thereof.

The State Department of Health has been designated the State water pollution agency pursuant to the Federal Water Pollution Control Act, as it is the State Health authority of New Mexico.

Texas

In 1913 Texas passed legislation prohibiting the pollution of any "watercourse or other public body of water." The State Board of Health was designated to enforce the provisions of the Act and the State Game, Fish and Oyster Commission was given permissive jurisdiction in the protection of fish and oysters. The State's anti-pollution statutes included injunction features under civil code as well as assessed fines under the penal code. In 1945 a General Sanitation Law was adopted which established minimum standards of sanitation and health protection measures and gave to the State Department of Health the specific responsibility for establishing necessary rules and regulations and the enforcement thereof.

The State Department of Health has been designated by the Surgeon General pursuant to the Federal Water Pollution Control Act as the State Water Pollution Agency.

Jurisdiction is State-wide and covers pollution of any water course or other public body of water from which water is taken for the uses of farm livestock, drinking and domestic purposes. The responsibility for prevention of pollution insofar as health is concerned is confined to the State Board of Health. Responsibility is shared with the Game, Fish and Oyster Commission, insofar as protection of fish and oysters is concerned.

Responsibility is further shared with all home rule cities which have the right to prevent pollution of their public water supply, and with all of the hundreds of water improvement and conservation districts, both for surface and sub-surface waters, which districts have the right to establish rules and regulations protecting water resources within the area of the district from pollution.

The State Land Commission is responsible for determining that oil well developments do not pollute surface and sub-surface waters of State owned lands. The enforcement of the Land Commission's rules and regulations is handled by the Game, Fish and Oyster Commission unless it involves pollution of water used for drinking, domestic purposes or livestock, when the State Health Officer assists in enforcement.

Colorado

No single agency is responsible for administering the various Colorado laws that pertain to water pollution. The Public Health Laws of 1947 gave the Department of Public Health broad general powers to deal with all phases of public health. No specific mention is made of water pollution as such.

The Game and Fish Department has the authority to enforce the Game and Fish Laws which, in part, make it unlawful to deposit sawdust, mill tailings, or other deleterious substances into any public waters containing fish.

Criminal statutes make it unlawful to pollute State watercourses, lakes, ponds and marshes.

The State Department of Public Health has been designated by the Surgeon General pursuant to the Federal Water Pollution Control Act as the State Water Pollution Agency.

Through the efforts of the State Health Departments, over 4,000,000 people, or two thirds of the basin total population were served by public sewerage systems on July 1, 1950. Further evidence of the excellent job done by the State Health Departments is the fact that approximately 94 percent of the sewered population was served by treatment plants.

As shown in Table C there were 162 primary sewage treatment plants and 312 secondary treatment plants in the basin on July 1, 1950. A large number of these plants were built many years ago and have outlived their usefulness and now need replacement. Many of the others, although adequate when constructed, were serving two and three times the number of people they were designed for and needed enlargement or additions to enable them to produce a satisfactory effluent.

An unusual situation developed at Houston, Tex. because the growth of the city was so rapid that existing small sewers could not be replaced by larger sewers at a rate fast enough to keep pace with the needs created by housing developments. This led to a policy of requiring each new development that could not be served by the city sewers to construct a complete sewerage system and treatment facilities. This policy, together with the annexation of several communities that already had treatment plants, resulted in the Houston area having 39 sewage treatment plants. These plants vary considerably in size, some serving populations of only 300 while others may serve over 300,000.

The amount of pollution wastes produced by industries operating within the basin was of considerable magnitude. However, the volume of pollution could not be estimated nor could the amount that actually reached the water resources be determined with data available.

Table D is a compilation of all industries, with separate waste outlets, for which information on industrial waste was available. This table indicates an industrial waste problem of considerable magnitude.

Of the 2,509 industries reported to be discharging wastes to the waters of the basin through separate outlets, 61 were known to have installed treatment facilities of some kind. Most, if not all, of the industries processing petroleum products have installed separators for the recovery of oils and the removal of sludge. In many cases emulsion-breaking treatment also is provided to improve oil recovery and to remove additional pollutants from the wastes produced.

Several of the industries located in the basin discharge their wastes into city sewerage systems following which they receive treatment at the municipal sewage plant. At several communities this procedure was reported to cause overloading of the municipal sewage treatment plant resulting in poor quality effluent. In most instances where such overloadings occurred, action to correct the condition, by increasing the capacity of the plant, was being taken.

As previously noted, many of the industries located in the arid sections of the basin dispose of their wastes by discharging them into evaporation basins. Many others make use of holding ponds or lagoons where wastes of varying characteristics are mixed to take advantage of any neutralizing effect, permitted to settle, and then discharged at controlled rates to the watercourse.

Table E is a summary of the adequacy of design and operation of existing treatment facilities on July 1, 1950. This also illustrates the need for improvement at many of these sewage and Industrial waste treatment plants.

The State water pollution control agencies are continuing and intensifying their efforts to improve operation, to secure additional treatment and to secure new sewage and industrial waste treatment facilities where needed. The efficiency of plant operation is being improved through a program of short schools for operators, technical meetings and by the licensing of plant operators.

Soil conservation projects were in operation in some parts of the basin and similar projects are being developed in many others. Factual data were not readily available on the amount of silt being kept out of the waters by these operations. Due to the large amount of natural silting the effect of soil conservation practices is not apparent by visual inspection of the streams. However, the Soil Conservation Service has some data indicating that in certain limited areas soil conservation practices are reducing the silt load to the streams by 30 to 40 percent or more.

Reinjection of oil well salt water wastes into subsurface strata is practiced throughout

Table C. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served [1]
	Municipalities*	Plants	
Primary	157	162[3]	425,972
Secondary	293[2]	312[4]	3,471,233
No treatment	35	0	258,291[5]

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

[1]Population served for 39 plants and independently sewered sub-division of Houston, Tex. was estimated by prorating total city population in accordance with sewage plant design data, as population served was not available for most of the Houston plants.

[2]Houston, Tex. is listed in this classification as most of its population is served by secondary treatment.

[3]Includes 5 primary plants in Houston, Tex. serving an estimated 10,000 persons.

[4]Includes 2 secondary plants in McKinney, Tex. and 18 secondary plants in Houston, Tex. serving an estimated 560,000 persons.

[5]Includes a population of 23,000 persons in 15 small independently sewered subdivisions in Houston, Tex. for each of which secondary treatment plants will be constructed.

the oil producing areas of the basin, particularly in the eastern fields. In many instances, however, holding ponds or lagoons are used to store salt water wastes. In some areas of the basin these stored brines are discharged into the streams at controlled rates during high river flows. In the arid regions of the basin, desiccating basins are used for the disposal of many of the industrial and oil field wastes. Large volumes of salt water pollution are kept out of the waters of the basin by these disposal methods.

The action taken by the Texas water pollution control agencies in correcting the salt water pollution of the Angelina-Neches River by the East Texas oil fields is a matter of record. This pollution was affecting municipal, industrial, and irrigation water utilized in the vicinity of Beaumont and Port Arthur, Tex. The situation is now well under control.

In the middle 1940's the city of Gonzales' water supply was being harmfully affected by oil field wastes originating in the Luling, Tex. area. Following detailed lease by lease surveys of the oil fields, a pollution hearing was held by the office of the Attorney General, the Game, Fish and Oyster Commission and the State Health Department, at which time the operators were requested to cooperate with the enforcement agencies in providing proper disposal facilities. After a 90-day correction period, a re-inspection of the field was held and legal action was initiated against offending operators, resulting in a temporary injunction being granted. Since that time the quality of the Guadalupe and San Marcos Rivers has materially improved,

Table D. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and allied.....	49	15	15	19
Textile mill.....	2	0	2	0
Paper and allied.....	3	3	0	0
Chemical and allied.....	29	12	12	5
Petroleum and coal.....	55	14	3	38
Rubber.....	6	6	0	0
Primary metals.....	1	0	1	0
Fabricated metals.....	13	6	--	7
Oil production (individual wells).....	2,313	--	--	2,313
Other mining.....	23	3	5	15
Miscellaneous.....	15	2	12	1
Total.....	2,509	61	50	2,398

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: Approximately 1,000 industries and 100,000 oil wells are operating in the basin. Except for those industries listed in this table no pollution data are available at this time.

although the enforcement agencies have had to initiate patrol action of the fields and have, on several occasions, reported violations of the injunction which has resulted in fines for contempt.

Early in 1950 a similar procedure was followed concerning salt water pollution originating in the Eastland County oil fields affecting the city of Temple, Tex. water supply, which is derived from the Leon River In this case, however, considerable corrective action was initiated by the operators and apparently legal action will not be necessary Along in 1950 a pollution hearing was held by the office of the Attorney General, the Texas Game, Fish and Oyster Commission, and the State Health Department, concerning the pollution of the San Antonio River by the city of San Antonio, Tex. This hearing was instrumental in accelerating the needed enlargement to the municipal sewage treatment plant, and construction was completed on a major portion of this project around the middle of 1950.

A similar hearing was held with reference to Texas City, Tex. and resultant pollution of Galveston Bay. As a result, that city has planned adequate sewage treatment facilities.

The office of the Texas Attorney General has been most cooperative with the Texas enforcement agencies in pollution matters and considerable precedent has been established in the legal aspects of pollution abatement work.

Table F shows the excellent progress that has been made in the last four years in abating stream pollution caused by municipal wastes within the Western Gulf Drainage Basin.

The progressive increase in the number of municipal waste treatment plants constructed since 1946 is indicative of the activities of the State pollution control agencies. The 99 plants installed during the years 1946 to 1949 inclusive, covered by Table F, have provided treatment facilities for approximately a million people. As indicated in Table H, the drive for needed corrective measures is continuing at an increased rate as evidenced by the fact that 54 sewage treatment plants were under construction in July 1950 to provide services for an additional million people. Interest in pollution abatement in the Western Gulf Drainage Basin is further indicated by the fact that 25 other municipalities had plans for treatment plants approved by the State agencies, while 32 others were actively engaged in preparing plans for abatement of sewage pollution.

As Table F indicates, no data were available concerning progress made since World War II in the construction of industrial waste treatment plants or the use of other pollution control measures.

Table E. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	474	247	212	15	185	207	82
Industrial	61	11	2	48	11	1	49

Table F. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	5	26,700	--	--
1947	21	114,700	--	--
1948	26	445,500	--	--
1949	47	294,350	--	--

POLLUTION PREVENTION MEASURES REQUIRED

The State pollution control agencies are aware of the need for continued evaluation of the water pollution problem to assist in the programs of pollution abatement. They are intensifying their efforts to fill in the information gaps, to improve operation of existing treatment facilities and to secure additional sewage and industrial waste treatment facilities where needed.

State funds made available to water pollution control agencies are inadequate to administer effectively a comprehensive program of pollution abatement in the basin. Present technical staffs for survey and investigational work and monies for control purposes are so limited that the accomplishment of the abatement programs will be considerably delayed. Benefits resulting from the pollution control programs will be similarly delayed. The procurement of additional personnel and funds with which to implement an adequate abatement program is a pressing need of the regulatory agencies.

The State agencies also lack funds for the dissemination of pollution abatement information to the public. This is a very desirable element of any comprehensive pollution control program. Promotion of community planning projects and their utilization with pollution abatement programs is also hampered in the Western Gulf Drainage Basin by inadequate State appropriations. Additional funds for this purpose are urgently needed by the State water pollution control agencies.

Although a great majority of the municipalities in the Western Gulf Drainage Basin had waste treatment facilities, considerable construction and reconditioning were needed before satisfactory pollution abatement could be realized. This situation has developed because many of the existing plants were so old that they were structurally unsound or lack adequate capacity to handle the increased loads placed upon them by the rapid population growth.

On July 1, 1950 it was estimated that it would be necessary to construct new or additional facilities at 255 communities if the domestic sewage originating in the basin is to receive adequate treatment. As shown in Table G, this included 43 new plants, the replacement of 94 obsolete plants and the increase in capacity and treatment at 118 plants.

A detailed list of facilities needed in each sub-basin is included in Table I for that sub-basin. The construction cost of the needed municipal sewage treatment facilities for the Western Gulf Drainage Basin was estimated to be $56,344,000. This estimate, based on July 1, 1950 needs, is for capital expenditures for plant construction only. It does not include costs of land, right of way, collecting sewers, intercepting sewers, etc., nor does it take into account maintenance and operating costs.

Recognizing that these expenditures will take place over a number of years the estimated costs might be increased due to added factors. These include additional annual obsolescence and rehabilitation requirements, needs of communities installing new sewerage systems, population increases and industrial expansion, as well as allowance for presently undetermined needs.

The total cost of all needed industrial waste treatment facilities cannot be estimated because of the large number of potential industrial wastes sources (which include over 100,000 operating oil wells) and the variety and complexity of industrial wastes treatment processes.

Large volumes of oil field brine wastes are now satisfactorily disposed of by injection into subsurface strata or by storage in holding basins. To adequately protect the waters of the basin from brine pollution many of these storage basins must be abandoned and subsurface disposal methods installed. The total number of subsurface disposal installations needed and the number of storage basins that require improvements is not presently known. Much time and study will be necessary before definite requirements can be ascertained and probable costs estimated.

Available information on the status of industrial waste pollution in the Western Gulf Drainage Basin contained so many unknown factors that it was impossible to evaluate the problem in respect to the pollution entering the waters of the basin, the effect of this pollution on the waters, and the treatment needs. The list of industries included in this report, is fairly complete for the eastern part of the Gulf Coast area, but is only a partial inventory of the total number of industries discharging wastes to the waters of the basin.

It would be helpful in determining the overall stream pollution problem if a complete listing of industrial plants discharging wastes to the streams and information on the amount and character of the wastes being discharged were obtained. Information is also desirable on the waste disposal methods now

Table G. Requirements for municipal and industrial waste treatment plants*

Requirements **	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	43***	257,608	--
Enlargement or additions to existing plant	118	1,081,310	--
Replace existing plant	94	764,250	--
No project required	252	1,949,692	11
Undetermined	17	102,636	2,498

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**For individual project needs refer to Table I contained in each of the sub-basin discussions which follow Part 1 of this report.

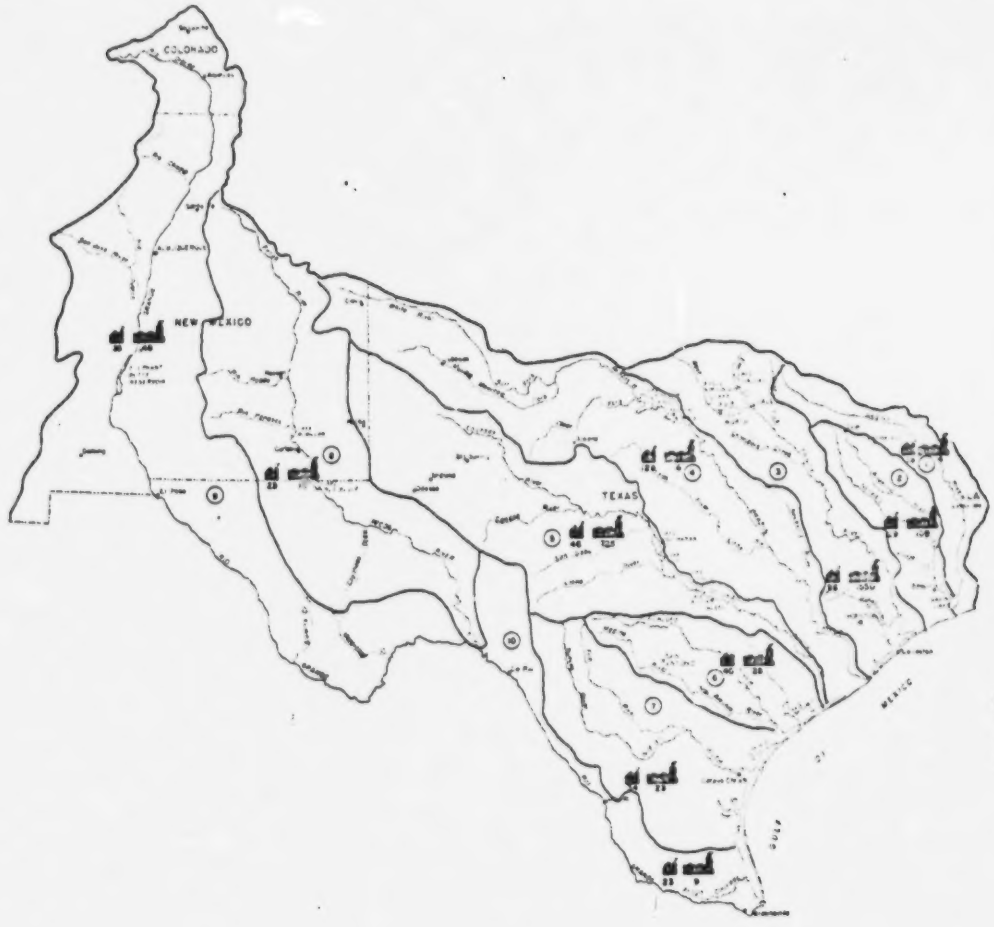
***Included are 15 new plants for the city of Houston, Tex. In addition, there are 14 communities with a population of 18,615 that do not have sewer systems at present for which both sewers and treatment plants are recommended.

being used, the amount of polluting material actually reaching the streams after treatment, and the effect, if any, of this pollution on the waters of the basin. Such information is important to formulate specific recommendations on the action needed to abate industrial waste pollution.

Soil conservation programs are well established. The continued heavy silt burden of the streams, however, indicates that more intensified and comprehensive programs, in this field are needed before silt pollution in the basin can be properly controlled.

Table H. Status of treatment works projects to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	149	--
Abatement ordered	0	--
Plans under preparation	32	--
Final plans approved	25	--
Construction awaiting financing	0	--
Under construction	54	--
Status undetermined	12	--



NOTE -
The 2536 industries for which data are available [illegible]
of data. In addition, there are approximately 650 industries and 100,000
of data pertaining to the basin for which waste data are not available.

SUB-BASIN INDEX

1. Sabine River Basin
2. Neches River Basin
3. Trinity and San Jacinto River Basin
4. Brazos River Basin
5. Colorado River Basin
6. Guadalupe, Lavaca and San Antonio River Basin
7. Nueces River Basin
8. Pecos River Basin
9. Rio Grande Basin, (Upper), Above Pecos River
10. Rio Grande Basin, (Lower), Below Pecos River

NUMBER OF MUNICIPAL SOURCES

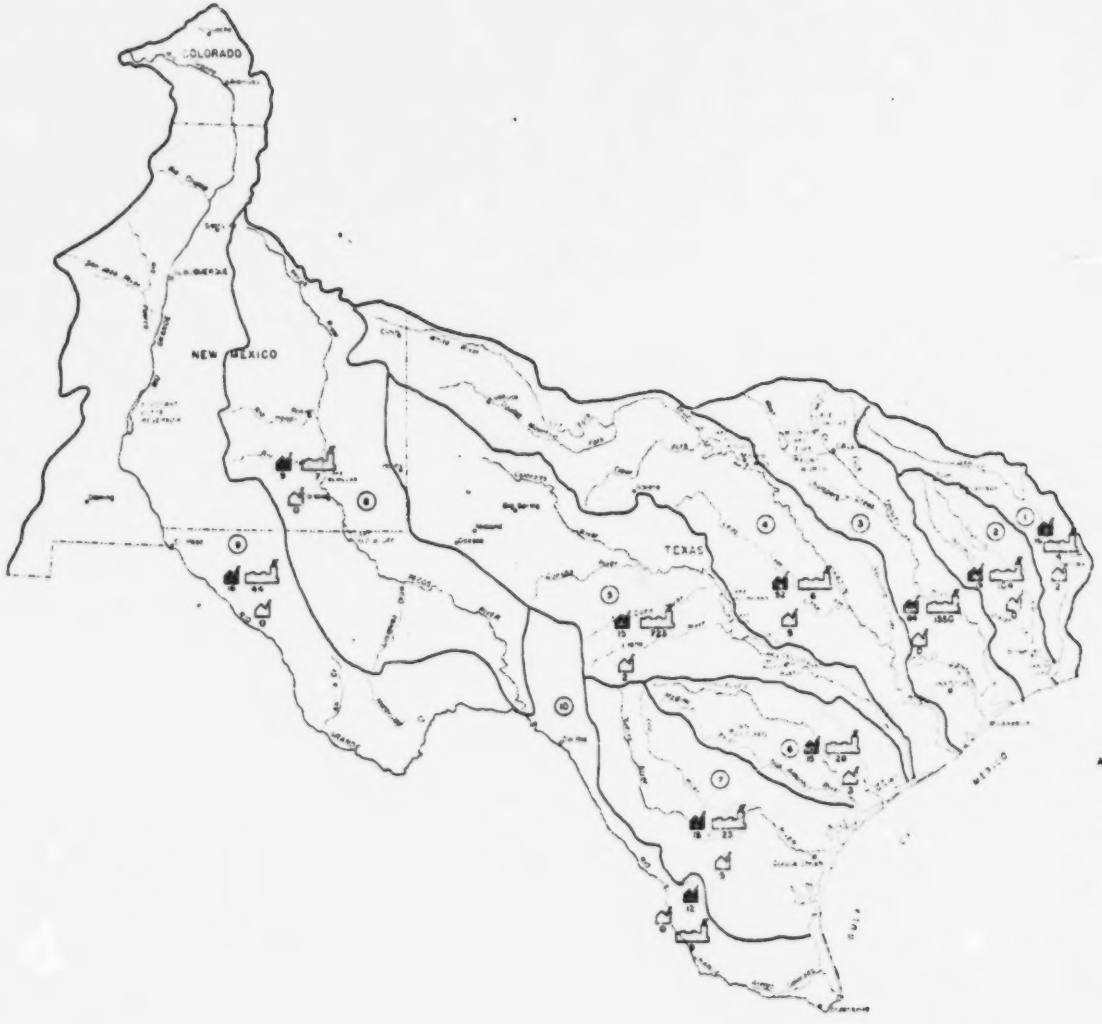
NUMBER OF INDUSTRIAL SOURCES

SCALE IN MILES
40 30 0 30 40 60 80 100 120 140

WESTERN GULF DRAINAGE BASIN
SOURCES OF POLLUTION
FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP NO. 1

18-A

[illegible] O - 53 (Face p. 16) No. 1



NOTE -
The 2538 industries for which data are available include 213 industrial oil wells. In addition, there are approximately 600 industries and 100,000 oil wells operating in the basin for which waste data are not available

SUB-BASIN INDEX

1. Sabine River Basin
2. Neches River Basin
3. Trinity and San Jacinto River Basin
4. Brazos River Basin
5. Colorado River Basin
6. Guadalupe, Lavaca and San Antonio River Basin
7. Nueces River Basin
8. Pecos River Basin
9. Rio Grande Basin (Upper), above Pecos River
10. Rio Grande Basin (Lower), below Pecos River

NUMBER OF MUNICIPAL PROJECTS REQUIRED

NUMBER OF MUNICIPALITIES WITH PROJECT REQUIREMENTS UNDETERMINED

NUMBER OF INDUSTRIAL PROJECTS REQUIRED

NUMBER OF INDUSTRIES WITH PROJECT REQUIREMENTS UNDETERMINED

SCALE OF MILES
40 20 0 20 40 60 80 100 120 140

WESTERN GULF DRAINAGE BASIN
PROJECTS REQUIRED
FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP NO 3

1823

982308 O - 55 (Face p. 18) No. 3

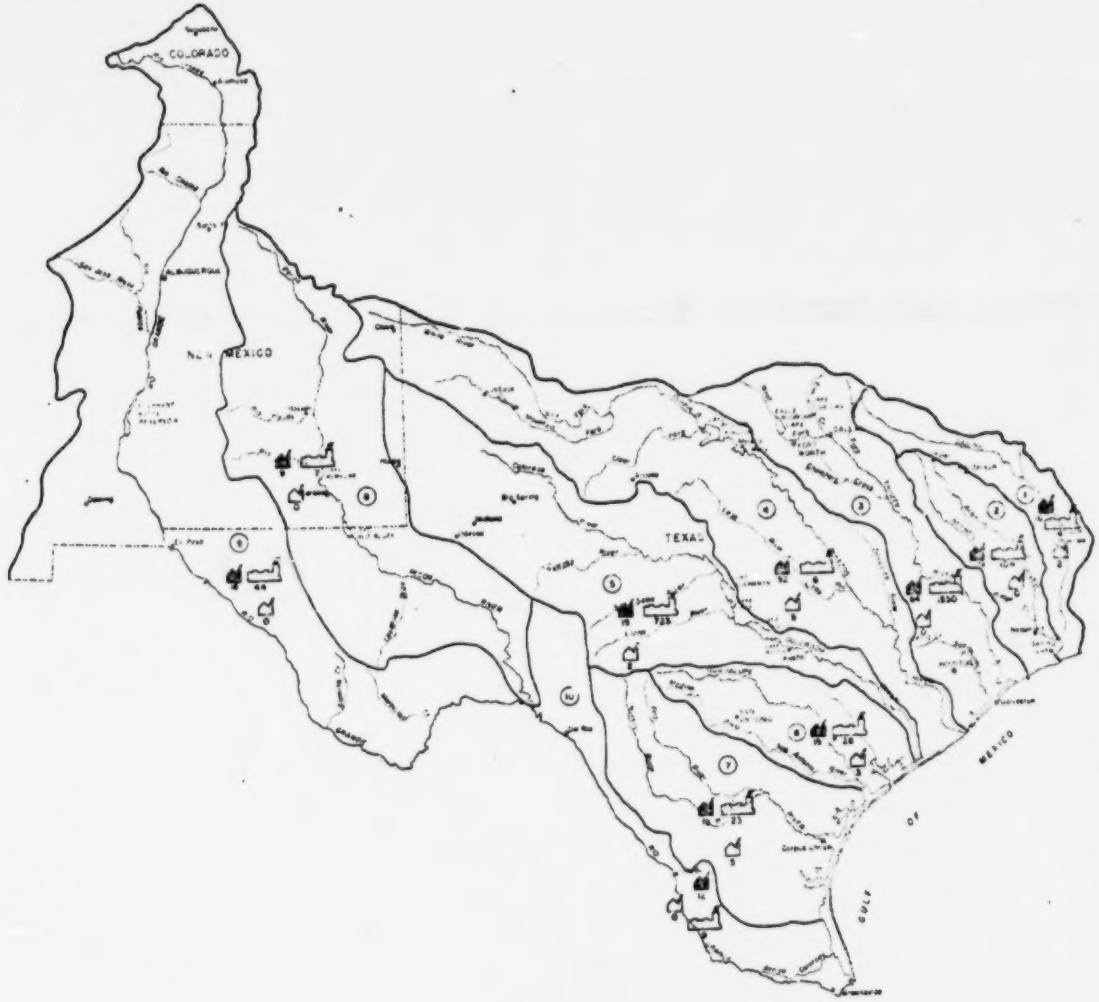
DOMESTIC WATER SUPPLY
INDUSTRIAL WATER SUPPLY
LIVESTOCK
IRRIGATION
COMMERCIAL FISHING
GAME FISHING
SHELLFISH
WILDLIFE
BATHING WATER
OTHER RECREATION
NAVIGATION

SCALE OF MILES
40 20 0 20 40 60 80 100 120 140

WESTERN GULF DRAINAGE BASIN
EXISTING PRIMARY WATER USES
FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP NO 4

18-C.

92358 O - 52 (Face p. 18) No. 4



NOTE -
The 2500 industries for which data are available include 23 municipalities and 1 industry in addition, there are approximately 600 industries and 400,000 acres appearing in the basin for which water data are not available.

SUB-BASIN INDEX

1. Sabine River Basin
2. Neches River Basin
3. Trinity and San Jacinto River Basin
4. Brazos River Basin
5. Colorado River Basin
6. Guadalupe, Lavaca and San Antonio River Basin
7. Nueces River Basin
8. Pecos River Basin
9. Rio Grande Basin,(Upper), above Pecos River
10. Rio Grande Basin,(Lower), below Pecos River

NUMBER OF MUNICIPAL PROJECTS REQUIRED

NUMBER OF MUNICIPALITIES WITH PROJECT REQUIREMENTS UNDETERMINED

NUMBER OF INDUSTRIAL PROJECTS REQUIRED

NUMBER OF INDUSTRIES WITH PROJECT REQUIREMENTS UNDETERMINED

SCALE OF MILES
40 20 0 20 40 60 80 100 120 140

WESTERN GULF DRAINAGE BASIN
PROJECTS REQUIRED
FEDERAL SECURITY AGENCY
Public Health Service
DIVISION OF WATER POLLUTION CONTROL
MAP NO. 3

18-D

882302 O - 52 (Face p. 18) No. 3

SUB-BASIN REPORTS

SABINE RIVER SUB-BASIN

The Sabine River Sub-Basin, predominately rural in character, is situated in eastern Texas and western Louisiana. It is a long narrow crescent shaped area larger than Massachusetts. The sub-basin is about 330 miles long and 20 to 30 miles wide and contains about 9,700 square miles, of which about 7,400 square miles are in Texas. The Sabine River is a turbid meandering stream rising in the sub-humid zone of Texas at an elevation of 500 feet in rolling agricultural country. It flows southeasterly about 200 miles, then turns south, forming the Texas-Louisiana boundary for about 180 miles, and passes through the humid zone before discharging via Sabine Lake into the Gulf of Mexico.

The northern half of the sub-basin is well developed farming country but also contains several large producing oil fields. Most of the sub-basin industry is dispersed throughout this upper area where petroleum, farm products, and natural salt deposits supply basic raw materials. The remainder of the sub-basin is largely forested and has a lumber and timber products industry. Close to the Gulf there is a limited industrial development. This area also supports cattle raising and rice cultivation.

Rainfall and river flows, although erratic, are adequate to supply present water use throughout the sub-basin except for the irrigation of rice. The flow in the river has been reversed occasionally during extreme low river stages when heavy irrigation pumping resulted in brackish water being drawn up from the tidewater areas. This brackish water is reported to have damaged rice crops. The construction of two large reservoirs in the Neches River Sub-Basin, which will supply water for the gulf area, including the lower part of the Sabine Sub-Basin, will insure adequate water for all foreseeable future demands.

There are approximately 395,000 people residing in the sub-basin with about 82,000 living in eleven municipalities of 2,500 persons or more. On July 1, 1950 there were 28 communities in the sub-basin that have public sewerage systems which serve a total of about 115,000 persons.

Pollution from municipal wastes generally is localized in the tributaries and has little adverse effect upon the main stream during normal flows. Only three sewered communities were without sewage treatment facilities. However, many of the existing treatment plants were old and needed replacement or enlargement if they were to produce satisfactory treatment at all times.

The condition of the streams was considered to be unsatisfactory immediately below 12 of the municipalities and at 11 of these locations a nuisance condition was reported. The stream conditions below municipalities were considered good in only 8 instances. It was estimated that adequate treatment of sewage could be secured by the construction of one new plant, the replacement of 5 plants and the enlargement of, or additions to 10 plants.

The principal industries in the sub-basin which might produce wastes inimical to water uses included 14 refineries and petroleum processing plants, 12 chemical plants, 12 dairy products plants, 12 food processing plants and 2 pulp and paper mills.

While data on industrial wastes are not complete, it was known that at least four industries in the Gulf area of the sub-basin discharge wastes directly to the streams. By use of production data and other available information it was estimated that organic wastes with a population equivalent of 23,900 persons were produced by the four industries. It was reported that all four of the industries had some type of treatment facility. Most of the industrial wastes found in the sub-basin originate in petroleum and food processing industries scattered throughout the upper area. The extent of treatment these wastes received, and the actual amount of pollution entering the surface waters of the sub-basin, could not be determined from the information available. This precludes an estimate of the treatment facilities needed to properly dispose of these wastes without detriment to surface waters.

Probably the major source of stream pollution in the Sabine Sub-Basin is brine wastes from the thousands of oil wells in the sub-basin. Many of these have reached peak oil production and have started stripping operations which produce large quantities of salt water wastes. Most of this waste is treated and injected into salt water strata. In some areas it is retained in holding ponds and released during periods when high river flows occur at times other than the rice growing season. Rice is reported to have been damaged by the salt wastes in the past, but the methods for

disposal now in operation in most of the basin are considered adequate if properly carried out. The present trend is toward elimination of holding ponds and toward increased injection of the wastes into salt water strata. This reduces the possibility of ponds overflowing or dykes breaking with resulting water pollution, crop loss and possible heavy damage suits.

The river carries a heavy silt-load especially during periods of high runoff. While pollution by silt is not as damaging in the Sabine Sub-Basin as it is in many of the western river basins, it is of considerable magnitude and the resulting siltation of the ship channels in the tidewater area requires extensive dredging to maintain proper channel depths.

Table A_1. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	0	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	28	114,851	Not applicable
Total	28	114,851	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage directly to watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_1. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	2	Undetermined
Producing inorganic wastes	1	Not applicable
Producing wastes of undetermined type	1	Undetermined
Total	4	--

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are approximately 14 refineries, 11 chemical plants, 12 dairy products plants, 11 food processing plants, and 1 pulp and paper mill and innumerable oil wells operating in this sub-basin for which no waste information is available at this time.

Table C_1. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	12	12	17,885
Secondary	13	13	74,550
No treatment	3	0	22,416

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

Table D_1. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and allied.....	1	1	0	0
Paper and allied.....	1	1	0	0
Chemical and allied.....	1	1	0	0
Fabricated metal.....	1	1	0	0
Total.....	4	4	0	0

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are approximately 50 industries and thousands of oil wells in the sub-basin for which no waste information is available at this time.

Table E_1. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	25	10	15	0	3	15	7
Industrial	4	--	--	4	--	--	4

Table F_1. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	--	--
1947	3	3,650	--	--
1948	4	11,800	--	--
1949	1	600	--	--

Table G_1. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	1	20,000	--
Enlargement or additions to existing plant	10	27,735	--
Replace existing plant	5	17,450	--
No project required	10	47,250	--
Undetermined	2	2,416	4

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_1. Status of treatment works projects to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	10	--
Abatement ordered	0	--
Plans under preparation	5	--
Final plans approved	1	--
Construction awaiting financing	0	--
Under construction	0	--
Status undetermined	0	--

Table I_1. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements	Remarks
Texas:			
Canton	1,200	Additions	--
Carthage	4,500	Replace plant	--
Celeste	500	Additions	--
Center	3,500	Additions	--
Cumby	450	Replace plant	--
Edgewood	1,035	Additions	--
Gladewater	4,200	Additions	--
Greenville	12,000	Additions	--
Kilgore	10,000	Replace plant	--
Lindale	1,000	Replace plant	--
Longview	20,000	New plant	--
Newton	1,200	Additions	--
Overton	2,000	Additions	--
Quitman	800	Additions	--
Royse City	1,500	Replace plant	--
Timpson	1,300	Additions	--

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Note: Available industrial waste information is not in sufficient detail to permit determination of industrial needs.

NECHES RIVER SUB-BASIN

The Neches River Sub-Basin is contained entirely within the State of Texas in the moist sub-humid and humid zones. It is about 250 miles long and 70 miles wide and has an area the size of the State of Maryland, about 10,100 square miles. The Neches River and its principal tributary, the Angelina River, are turbid and meandering streams with gentle gradient. They rise at an elevation of about 550 feet in rolling agricultural country in which several large producing oil fields are located. Petroleum and gas from these oil fields and cotton and other farm products are used as basic materials for industry which has developed in the upper portions of the sub-basin.

In general, pollution of surface waters in this upper area is localized in the tributaries near municipalities and industrial areas and is reported to cause little damage. The exception is pollution from oil well brine wastes which constantly threaten water uses. Most of the brine wastes are retained in holding ponds or treated and then injected into the ground. The volume of brine wastes is increasing in this area because many wells have reached peak oil production and have started stripping operations with attendant greater brine production.

In the central portion of the sub-basin the rivers flow southeasterly through a timbered area in which lumbering and timber products industries are active. Little waste was discharged to the surface water in this central area except at Lufkin, where municipal wastes and pulp and paper wastes enter the Angelina. Most of these municipal and industrial wastes received treatment sufficient to prevent damage to the river during normal flows.

It is in this undeveloped timber area of the sub-basin, at the confluence of the Neches and Angelina Rivers, that a group of dams are being constructed to store water for use by municipalities, industries, and for rice irrigation in the Gulf area of the Sabine, Neches and Trinity River Sub-Basins. Two of these dams form immense reservoirs, one, McGee Bend, will have a surface area of 140,000 acres and usable storage capacity of 3,287,000 acre-feet, and the other, Rockland, will have a surface area of 122,000 acres and usable capacity of 1,035,000 acre feet. According to Circular No. 23, March 1948, of the U. S. Department of Interior, only six reservoirs in the United States, at that time, had a usable capacity greater than that of McGee Bend. Only one reservoir, Lake Okeechobee of Florida, had a surface area greater than that of these two reservoirs. Seven had areas greater than McGee Bend while only eight are larger than Rockland. In addition to supplying a dependable water supply for the Gulf area, these reservoirs will greatly increase the recreation and fishing facilities of the sub-basin.

The southern portion of the sub-basin is level country where cattle raising and rice cultivation are the principal agricultural pursuits. Rice irrigation requires large quantities of clean water which has been difficult to secure at times because of low flows, some salt water pollution from oil fields, and brackish water which is drawn up from tidal estuaries during periods of heavy demand. The large reservoirs previously mentioned should alleviate these conditions.

A relatively heavy concentration of industry has developed in the tidewater area of the sub-basin, using petroleum and gas as their basic raw materials. There have been no reported instances of pollution adversely affecting industrial water supplies, which are used for processing and cooling, at a rate of about one-half billion gallons per day.

During use by industry this water picks up an organic pollution load estimated to be equivalent to that produced by the sewage of about 550,000 people. This pollution is reported to have damaged fishing in the affected areas but to have caused little other damage.

The major uses of surface waters in the sub-basin are for domestic and industrial water supplies and for rice irrigation. Most of the domestic water supplies are obtained from wells and the few surface supplies used are taken from tributaries which are not affected by pollution. In the lower portion of the sub-basin, rice irrigation uses tremendous quantities of water. This is a seasonal use and varies according to the rainfall occurring during the irrigating season. Actual water demand figures are difficult to secure but the allocated permissible use has been set at 1,035,000 acre-feet per year. At times, pollution has affected the rice crop and the chemicals originating in oil well brine wastes were suspected as the damaging agent. The action taken by the pollution control agencies has resulted in the installation of brine disposal methods which have the situation well under control.

The sub-basin population was over 460,000 in 1940 with approximately 169,500 persons

living in municipalities of 2,500 or more. Two cities in the tide water area, Beaumont and Port Arthur, accounted for 105,200 of this urban population.

Most of the pollution caused by municipal wastes came from Beaumont and Port Arthur which discharge untreated wastes into tide-water. The balance came from the untreated wastes from four small municipalities, and from the waste-treatment plant effluents of 23 communities.

Table A2. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	0	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	29	269,520	Not applicable
Total	29	269,520	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

**Includes industrial wastes discharged into municipal systems.

The industries located in the sub-basin included 10 refineries, 20 chemical plants, 10 meat packing plants, 6 canneries, 19 dairy products plants and 1 pulp and paper mill. The number of industries that discharge wastes directly to the watercourse was not known.

Eleven of these industrial plants were known to have treatment facilities. One waste treatment plant for which data were available was reported to be adequate in both capacity and operation.

By the use of production data, the industrial wastes from manufacturing plants in the lower portion of the sub-basin were estimated to have a population equivalent of 649,000. Petroleum and chemical industries produce the bulk of this pollution. Most of these wastes received some treatment before discharge into the streams, but the extent of treatment was unknown.

Oil well brine wastes are one of the major pollutants entering the streams of the sub-basin. Oil fields lying wholly or partially in the sub-basin produce tremendous amounts of brine wastes. A large portion of these are injected back into sub-surface strata and much of the balance is kept in holding ponds. It has been reported [1] that pollution from refinery wastes in the vicinity of Beaumont has seriously affected fish and wildlife.

Data on July 1, 1950 indicated that to adequately treat the municipal wastes in the sub-basin would require the construction of four new plants, the enlargement of eight and the replacement of seven.

Information on required industrial waste treatment facilities could not be determined for either industrial plants or oil fields with the information available.

[1] Fish and Wildlife Service; see report: Information on Specific Problems of Water Pollution, Division of Water Pollution Control --January, 1949.

Table B_2. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	11**	Undetermined
Producing inorganic wastes	94***	Not applicable
Producing wastes of undetermined type	8	Undetermined
Total	105†	--

*Industries having separate outlets and discharging wastes directly to watercourse.

**Include 8 plants also producing inorganic wastes.

***Includes 86 individual oil wells.

†Total adjusted to correct for duplication noted in footnote marked thus**.

Note: There are approximately 10 refineries, 20 chemical plants, 10 meat packing plants, 6 canneries, 19 dairy products plants and innumerable oil wells operating in the sub-basin for which no waste information is available.

Table C_2.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	11	11	13,550
Secondary	12	12	115,170
No treatment	6	0	140,800

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

Table D_2. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and allied.....	2	0	2	0
Paper and allied.....	1	1	0	0
Chemical and allied.....	6	3	1	2
Petroleum and coal.....	7	5	1	1
Rubber.....	2	2	0	0
Fabricated metal.....	1	--	--	1
Oil production (individual wells).....	86	--	--	86
Total.....	105	11	4	90

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are approximately 65 industries and thousands of oil wells in the sub-basin for which no waste information is available at this time.

Table E_2. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	23	8	15	0	9	12	2
Industrial	11	1	--	10	1	--	10

Table F_2. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	--	--
1947	0	--	--	--
1948	1	5,000	--	--
1949	1	6,000	--	--

Table G_2. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	4	139,200	--
Enlargement or additions to existing plant	8	49,550	--
Replace existing plant	7	42,400	--
No project required	10	38,370	1
Undetermined	0	--	104

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_2. Status of treatment works projects to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	15	--
Abatement ordered	0	--
Plans under preparation	2	--
Final plans approved	0	--
Construction awaiting financing	0	--
Under construction	2	--
Status undetermined	0	--

Table I_2. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements	Remarks
Texas:			
Alto	1,000	Additions	--
Arp	450	Additions	--
Beaumont	70,000	New plant	--
Corrigan	1,000	Additions	--
Cushing	500	Additions	--
Daisetta	3,200	New plant	--
Diboll	200	Replace plant	--
Frankston	900	Replace plant	--
Garrison	600	Additions	--
Henderson	12,000	Replace plant	--
Jasper	4,000	Replace plant	--
Nacogdoches	12,000	Replace plant	--
Nederland	2,000	Additions	--
Palestine	12,000	Replace plant	--
Port Arthur	60,000	New plant	--
Port Neches	6,000	New plant	--
Tyler	42,500	Additions	--
Woodville	1,500	Additions	--
Troup	1,300	Replace plant	--

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Note: Available industrial waste information is not in sufficient detail to permit determination of industrial needs.

TRINITY RIVER SUB-BASIN

The Trinity River Sub-Basin is a long narrow area twice as large as Maryland containing about 21,000 square miles and lying entirely within the eastern half of Texas. The Trinity River is a turbid meandering stream with gentle gradient rising at an elevation of about 1,250 feet and flowing 700 miles to the Gulf of Mexico. The northwest portion of the sub-basin is situated in the central lowland province of the Interior Plains and the remainder of the sub-basin is in the West Gulf Coastal Plain.

The average annual precipitation varies from 28 inches at the headwaters to 45 inches at the Gulf. Maximum 24 hour rainfall on record is 14.21 inches. Rainfalls of eight to nine inches in 24 hours occur occasionally. Stream flows vary from year to year and markedly from season to season. Periods of zero flow have occurred at all gaging stations on the tributaries of the Trinity River. Zero flows have also been recorded at all stations on the main stem (West Fork) above and including Dallas, except at Grand Prairie where the minimum observed flow was 4.5 cubic feet per second. The gage reading at this station does not represent natural low-water flow, because the City of Fort Worth releases a considerable flow of municipal wastes into the stream above. The maximum flood discharge on the Trinity River was 184,000 cubic feet per second at Dallas. That flood progressively decreased as it moved down stream until it was only 52,200 cubic feet per second when it reached Liberty, the lowest gaging station on the river at that time. This rapid decrease of flood flow is characteristic of all major floods on the Trinity and is attributable to the natural controls in the river and to the immense valley storage between the controlling points. The San Jacinto River which drains but one-seventh of the sub-basin has flood flows of much greater magnitude than occur on the Trinity which drains six times as much area. The average annual discharge of the Trinity River is 6,136,000 acre-feet and the average annual discharge of the San Jacinto River is 2,063,500 acre-feet.

Eight large reservoirs have been constructed in the sub-basin and four others are now under construction. These reservoirs will provide about 2,750,000 acre-feet of storage and will be of great value in storing flood waters for later release to augment low flows.

The Trinity Sub-Basin is the most densely populated area in the Western Gulf Drainage Basin. With only five per cent of the land area of the basin, it had over 1,800,000 people or approximately 30 per cent of the total 1940 basin population. The four large cities of the sub-basin had estimated 1949 metropolitan populations as follows: Houston 670,000; Dallas 525,000; Fort Worth 353,000 and Galveston 90,000.

Except for two industrial areas, the sub-basin economy is predominately agricultural. About 75 per cent of the total area is in farms which have about 3,500,000 acres under cultivation. The greater part of the area not in farms is forested and supplies timber and wood products for industry.

The Trinity Sub-Basin might well be called the industrial center of the Southwest. The two industrial areas of Dallas-Fort Worth and Houston-Galveston are rapidly growing manufacturing centers with almost every known type of industry.

In 1941, Dallas ranked fifth among the cities of the nation as a clothing manufacturing center and Fort Worth, in 1936, held sixth position among the leading meat packing and livestock marketing centers of the United States. Throughout the rest of the sub-basin, manufacturing is devoted to processing raw materials from farm, forest and mineral deposits. The principal industries which may produce wastes inimical to legitimate water uses include thousands of oil wells, 41 refineries, 94 chemical plants, 54 dairy products plants, 44 meat processing plants, 18 canneries, 4 breweries and many sea food processing plants.

There were 33 industries and 1,517 oil wells which may discharge wastes directly to the waters of the sub-basin. With the exception of 3 small industries these are all located in the Gulf area. No information was available for the industries in the Dallas-Fort Worth industrial area and in the rest of the sub-basin.

Municipal water supplies require about 100,000,000 gallons of ground water and 75,000,000 gallons of surface water daily. Industry uses an estimated 30,000,000 gallons of surface water and 110,000,000 gallons of ground water per day. Irrigation is the largest user of water and during the 130 day irrigation season about 480,000,000 gallons of surface water and 225,000,000 gallons of ground water are used each day.

There is an abundance of surface water in the sub-basin if controlled, for all present and foreseeable future needs. However, the stream flows vary to such an extent that there

are periods when the flow in the streams is barely large enough for present water uses.

Competent observation indicates that the Trinity River Sub-Basin with its concentration of population and industries has the most serious pollution problems of any sub-basin in the Western Gulf Drainage Basin.

The lack of water in the upper Trinity accentuates the pollution during low water periods, and the effect of the pollution from the Fort Worth and Dallas areas is especially noticeable in the river from Fort Worth to the Gulf. At irregular intervals water is released from reservoirs above, for the purpose of clearing the channel of sewage, but this results in what are locally known as "black rises" which according to the National Resources Committee creates a serious health menace, kills fish, and causes other nuisances throughout the basin.

Table A_3. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people) **
Having data on pollution load discharged to watercourse	0	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	98	1,700,990	Not applicabl
Total	98	1,700,990	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

In 1890 the Galveston area produced commercially 1,112,000 pounds of trout, redfish and sheepshead, while in 1948 the entire bay fisheries catch of the Galveston area totalled only 336 pounds. Three factors are reported as responsible for the spectacular decline in the Galveston Bay fisheries. In the indicated order of importance, these are siltation, pollution and overfishing. It should also be noted that, at the present time, because of sewage contamination, the Texas State Health Department prohibits the sale for food of all Galveston Bay oysters. At the present time a sanitary survey of the waters in Galveston County is being initiated.

It is reported[2] that: (1) Pollution from Dallas and Fort Worth has seriously damaged the value of fish and wildlife of the Trinity River for 100 miles; (2) pollution by domestic sewage from Fort Worth has seriously affected fishing, waterfowl habitat, trapping and hunting on the West Fork of the Trinity River for 30 miles; (3) dredging operations have destroyed oyster beds in the Gulf of Mexico Coast from Copano Bay to Galveston Bay. Dredge waste, probably oil, is considered the cause of pollution, and (4) fishing has been seriously damaged in Buffalo Bayou by domestic sewage and industrial wastes from Houston.

Much of this damaging pollution will be eliminated by presently contemplated municipal and industrial wastes treatment plants.

In common with the other sub-basins, the Trinity has thousands of operating oil wells which produce large volumes of brine wastes. Present disposal practices keep much of this waste out of the sub-basin waters.

It was estimated that adequate treatment of municipal sewage in this sub-basin would require the construction of 20 new plants, the replacement of 31 existing plants and additions to or enlargement of 33 others. Facilities needed to correct or eliminate industrial waste pollution could not be ascertained with available information due to the complexity of industrial waste treatment.

[2]See footnote on page 24.

Table B_3. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)**	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	13**	Undetermined
Producing inorganic wastes	1,526***	Not applicable
Producing wastes of undetermined type	17	Undetermined
Total	1,550/	--

*Industries having separate outlets and discharging wastes directly to watercourse.

**Includes 6 plants also producing inorganic wastes.

***Includes 1,517 individual oil wells.

/Total adjusted to correct for duplication noted in footnote marked thus**.

Note: There are approximately 41 refineries, 94 chemical plants, 54 dairy products plants, 44 meat processing plants, 18 canneries, 4 breweries, many sea food processing plants and thousands of oil wells operating in the sub-basin for which no waste information is available at this time.

Table C_3.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served [1]
	Municipalities*	Plants	
Primary	35	40[3]	67,950
Secondary	58[2]	77[4]	1,577,040
No treatment	5	0	56,000[5]

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

[1]Population served for the 39 plants and independently sewered subdivisions of Houston, Tex. was estimated by prorating total city population in accordance with sewage plant design data. Data on population served not available.

[2]Houston, Tex. is listed in this classification as most of its population is served by secondary treatment.

[3]Includes 5 primary plants in Houston serving an estimated 10,000 persons.

[4]Includes 2 secondary plants in McKinney, Tex. and 18 secondary plants in Houston, Tex. serving an estimated 560,000 persons.

[5]Includes a population of 23,000 in 15 small independently sewered subdivisions in Houston for each of which secondary plants will be constructed.

Table D_3. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and allied.....	4	2	--	2
Textile mill.....	1	0	1	0
Paper and allied.....	1	1	0	0
Chemical and allied.....	11	6	4	1
Petroleum and coal.....	6	6	0	0
Rubber.....	3	3	0	0
Fabricated metal.....	4	2	--	2
Oil production (individual wells).....	1,517	--	--	1,517
Miscellaneous.....	3	1	2	0
Total.....	1,550	21	7	1,522

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are approximately 250 industries and thousands of oil wells in the sub-basin for which no waste information is available at this time.

Table E_3. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	117	53	64	0	40	56	21
Industrial	21	--	--	21	--	--	21

Table F_3. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	--	--
1947	5	30,500	--	--
1948	2	340,100	--	--
1949	14	73,050	--	--

Table G_3. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	20**	59,325	--
Enlargement or additions to existing plant	33	414,350	--
Replace existing plant	31	89,400	--
No project required	53	1,137,915	--
Undetermined	0	--	1,550

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**In addition there is one community with a population of 525 that does not have a sewer system at present for which both sewers and treatment plants are recommended. This requirement is listed in Table I_9.

Table H_3. Status of treatment works projects to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	40	--
Abatement ordered	0	--
Plans under preparation	8	--
Final plans approved	16	--
Construction awaiting financing	0	--
Under construction	17	--
Status undetermined	3	--

Table I$_3$. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements	Remarks
Texas:			
Alvarado	1,500	Additions	--
Alvin	3,050	Additions	Preparing plans
Arlington	8,000	Additions	--
Athens	5,000	Replace plant	--
Baytown	18,000	Additions	--
Blooming Grove	450	Replace plant	--
Bowie	4,300	Replace plant	--
Bridgeport	2,010	Additions	--
Buffalo	750	New plant	Plans approved
Celina	1,000	Additions	--
Centerville	900	New plant	Plans approved
Coldspring	400	New plant	--
Coolidge	600	Additions	--
Corsicana	10,000	Replace plant	Plans approved
Crandall	525	New plant	Plans approved
Dayton	1,020	Replace plant	--
Deer Park	500	Replace plant	--
Dickinson	800	Replace plant	Under construction
Ennis	6,500	Replace plant	Preparing plans
Farmersville	1,700	Replace plant	--
Ferris	1,500	Replace plant	--
Forney	1,500	Additions	Under construction
Fort Worth	300,000	Additions	Under construction
Frisco	500	Additions	--
Frost	450	Replace plant	Under construction
Galena Park	6,000	Replace plant	Preparing plans
Galveston	25,000	New plant	Plans approved
Grand Prairie	14,000	Replace plant	Under construction
Grapevine	1,200	Replace plant	--
Groveton	1,000	Replace plant	--
Handley	3,000	Additions	--
Houston:			
1. Carolina Gardens	1,140	New plant	Plans approved
2. Carver Crest	1,600	New plant	Plans approved
3. Chocolate Bayou Est.	4,000	New plant	Under construction
4. Clinton Park	3,700	Additions	Preparing plans
5. Glenmore Forrest	315	New plant	Under construction
6. Garden Villa	3,000	Additions	--
7. Greenfield Add.	500	New plant	Plans approved
8. Highlands	5,000	Additions	Plans approved
9. Home Owned Est.	1,250	New plant	Plans approved
10. Homestead Add.	2,100	Replace plant	Plans approved
11. Lamar Terrace	3,760	New plant	Under construction
12. Manchester	1,000	Additions	--
13. North Park	300	New plant	Plans approved
14. Oakwood	300	Replace plant	--
15. Pinewood Village	2,000	New plant	Plans approved
16. Ridgecrest Add.	2,500	New plant	Under construction
17. Saddlebrook Add.	400	New plant	Plans approved
18. South Houston	4,400	Additions	--
19. South Crest	2,100	New plant	Under construction
20. South Side Place	2,910	New plant	Under construction
21. Sunnyside Gardens	1,000	New plant	Plans approved
22. SCID #2	2,500	New plant	Under construction
Hubbard	1,000	Replace plant	Preparing plans
Humble	2,000	Additions	--

See footnotes at end of table

Table I$_3$. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950--Continued

Name	Population served	Project requirements	Remarks
Jacinto City	2,500	Replace plant	--
Jacksboro	2,000	Replace plant	Under construction
Kaufman	3,000	Additions	--
Kemp	1,000	Additions	--
Kerens	1,400	Replace plant	--
Lamarque	6,000	Additions	Preparing plans
Leonard	1,000	Additions	--
Liberty	3,090	Additions	--
Lovelady	200	Replace plant	--
Mabank	1,000	Additions	--
McKinney	10,000	Additions	Under construction
Malone	300	Additions	--
Mansfield	980	Replace plant	--
Mesquite	1,800	Replace plant	Plans approved
Mexia	5,500	Replace plant	Planning improvements
Midlothian	1,400	Replace plant	--
Milford	800	Replace plant	--
Palmer	500	Replace plant	--
Pasadena	22,000	Additions	Under construction
Pilot Point	1,000	Additions	--
Richardson	1,000	Replace plant	Under construction
Rockwall	1,500	Additions	--
Saint Jo	800	Additions	--
Seagoville	700	Additions	--
Teague	2,200	Additions	Planning improvements
Terrell	12,000	Replace plant	--
Texas City	6,000	New plant	Under construction
Trinity	1,500	Additions	--
Van Aletyne	1,500	Replace plant	--
Wortham	1,000	Additions	--

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Note: Available industrial waste information is not in sufficient detail to permit determination of industrial needs.

BRAZOS RIVER SUB-BASIN

The Brazos River Sub-Basin is a long narrow area the size of Pennsylvania. It is 650 miles long, 60 to 100 miles wide with an area of about 44,670 square miles of which 42,000 are in Texas and the balance in New Mexico. The Brazos river rises in eastern New Mexico on a broad, semi-arid, plateau at an elevation of 4,000 feet and flows 1,210 river miles southeasterly across the State of Texas to the Gulf of Mexico. About 200 miles from the headwaters, the river drops from the plateau and flows through strongly rolling and deeply dissected plains country until it reaches the Balcones Fault Zone about 410 river miles from its mouth, where the elevation drops to about 400 feet. Below this fault zone the river flows through gently sloping prairies of the moist sub-humid zone until it reaches the Gulf.

Average annual rainfall varies from 18 inches in the headwaters to 45 inches at the Gulf. The entire sub-basin is subject to heavy rainstorms, the gulf area to tropical hurricanes, and the upper area to sand and dust storms. One major storm averaging eight inches of rainfall over an area of 66,000 square miles had a maximum rainfall, near the center of the Brazos Sub-Basin, of 33 inches in three days.

About 9,240 square miles of arid lands in the upper area of the sub-basin are considered non-contributing to the river flows because runoff occurs only in extremely rare instances. The Brazos River at South Bend, Tex., near the head of Possum Kingdom Reservoir, frequently has zero flow although the drainage area above that point is 21,600 square miles. Average annual runoff for the sub-basin is 6,000,000 acre-feet with annual variations from 1,240,000 to 16,120,000 acre-feet.

Six large reservoirs now existing, under construction, or for which bids are being received, together with nine reservoirs that are proposed for future construction, will virtually control the entire flow of the major rivers of the sub-basin and store flood water for irrigation, power, and other uses during low flow periods. The total storage capacity of these fifteen reservoirs will be more than 10,000,000 acre-feet. Many smaller reservoirs, of which 24 have capacities between 1,000 and 75,000 acre-feet, are located throughout the sub-basin. The water from these reservoirs is used for power, for municipal and industrial supplies, and for irrigation of lands that include 70,000 acres of rice in the gulf area.

Underground water sources are relied upon to supply the water needs in the semi-arid, high plains section of the upper portion of the sub-basin. At present, about 800,000 acres of farm land in the Brazos Sub-Basin are being irrigated from a large underground reservoir situated in the Brazos and Colorado River Sub-Basins. This reservoir is estimated to have a capacity of 95,625,000 acre-feet.

The central portion of the sub-basin has an impervious rock outcrop with the geological dip away from the area to the northwest and southeast. This precludes the occurrence of any large underground water reservoirs, and most of the municipalities and industries in this area depend upon surface water supplies. The few existing wells draw from localized pockets. The lower portion of the sub-basin has ample surface and underground water for present use and completion of the many proposed reservoirs will provide for all anticipated future needs.

Because of the intermittent nature of the streams in the upper half of the sub-basin, fishing and water recreation are practically nonexistent except in the storage reservoirs. The rest of the sub-basin has more permanent streams and they, as well as the reservoirs, offer fishing and recreation.

The industry of the sub-basin has been developed around petroleum and farm products and it is quite uniformly distributed throughout the sub-basin with no exceptional concentration in any one area. There are no reported cases of industrial water use being adversely affected by pollution.

Thousands of oil wells are operating in the many oil fields located throughout the sub-basin. The brine wastes from these wells are probably the greatest possible source of stream pollution in the sub-basin with the exception of silt. In one instance, a city water supply was threatened by the high chloride content on the Leon River from which the city obtains its supply. Correction of the methods of disposal of the brine wastes in the headwaters area alleviated the condition and prevented damage to the domestic water supply.

Oil well brine wastes produced annually in the sub-basin contain large quantities of salt. Much of this polluting material is kept from the surface waters by impoundment in evaporation ponds or by treatment and injection into the ground. The amount of brine actually reaching the streams is still unknown.

The silt load of the river is estimated to be over 40 million tons or 27,000 acre-feet per year. Siltation of Possum Kingdom Reservoir

located in the central portion of the sub-basin is estimated to be advancing at the rate of 7,000 acre-feet per year.

There is severe mineral pollution from natural resources in the headwaters of the sub-basin. Salt Fork, one of the two streams forming the Brazos, contains such high concentrations of natural salts that its water is unfit for any normal use except power production. It is reported that the entire flow of the other main stream, Double Mountain Fork, is insufficient during normal conditions to dilute the natural salt content enough to permit use of the Brazos River for any purpose but power production. It is only through addition of the relatively clear and low mineral water of Clear Fork and the storage of flood waters in the Possum Kingdom Reservoir that enough dilution of this natural pollution occurs to permit the Brazos River below the reservoir to be used for stock watering, irrigation, and municipal supplies.

Over 98.5 percent of the sewered population of 511,000 were served by waste treatment facilities. Twenty-five of the communities that had sewage treatment facilities applied the treated sewage to land, discharged it to closed basins, or used it for irrigation. The treatment plant effluents from these municipalities seldom, if ever, reach running water and are not considered a factor in surface water pollution. Many of the sewage plants were constructed years ago and, though the sub-basin was well supplied with treatment facilities, several municipalities had outgrown the capacities of their treatment plants or had plants that were antiquated and needed replacement. The condition of the streams was considered unsatisfactory immediately below 62 municipalities and at 56 of these locations a nuisance condition was reported. To correct and improve the stream conditions caused by municipal wastes pollution would require 6 new plants, enlargement of or additions to 29 and the replacement of 17 (Based on July 1, 1950 data).

Many of the industries in the sub-basin produce waste which may cause pollution of the receiving watercourse if not properly treated. These include 18 refineries and petroleum processing plants, 18 chemical plants, 33 dairy products plants, eight cheese plants, 20 plants processing cotton seed or peanuts, ten meat packing plants, five rendering and soap plants, a rubber plant, a sugar refinery, canneries and textile mills.

The number of industries discharging wastes directly to the waters of the sub-basin was unknown. Six industries discharged wastes directly to the streams. Industrial waste treatment facilities were provided at three of the six plants, but the extent of these facilities and the effectiveness of treatment were not known. The available data for existing industrial wastes and treatment facilities precluded any accurate estimation of the needs of the sub-basin in respect to industrial waste treatment or control.

It is reported[3] that 15 miles of the Bosque River are polluted by municipal wastes from Stephenville, Tex., to the extent that excellent fishing has been greatly reduced. This condition was being corrected. It is also reported that caustic soda in the waste of an industrial plant near Freeport, Tex. has caused periodic fish losses in the coastal waters of the Gulf of Mexico.

Table A4. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	0	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	129	510,788	Not applicable
Total	129	510,788	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

[3]Fish and Wildlife Service; see report: Information on Specific Problems of Water Pollution, Division of Water Pollution Control, January, 1949.

Table B_4. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	3	Undetermined
Producing inorganic wastes	1	Not applicable
Producing wastes of undetermined type	2	Undetermined
Total	6	--

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are approximately 18 refineries, 18 chemical plants, 33 dairy products plants, 8 cheese plants, 20 plants processing cotton seed and peanuts, 10 meat packing plants, 5 rendering and soap plants, and innumerable oil wells operating in the sub-basin for which no waste information is available at this time.

Table C_4.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	45**	45	77,192
Secondary	78***	78	421,746
No treatment	6	0	11,850

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

**Includes 6 municipalities that discharge plant effluent to dry washes or ponds which are not connected to running water except during heavy rainstorms.

***Includes 19 municipalities that use irrigation, land application or evaporation ponds as part of treatment.

Table D_4. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and allied.....	1	1	0	0
Textile mill.....	1	0	1	0
Chemical and allied.....	1	1	0	0
Rubber.....	1	1	0	0
Fabricated metal.....	1	--	--	1
Miscellaneous.....	1	0	1	0
Total.....	6	3	2	1

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are approximately 112 industries and thousands of oil wells in the sub-basin for which no waste information is available at this time.

Table E_4. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	123	72	46	5	50	52	21
Industrial	3	--	--	3	--	--	3

Table F_4. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	2	3,500	--	--
1947	4	9,750	--	--
1948	4	18,550	--	--
1949	13	75,200	--	--

Table G_4. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	6	11,850	--
Enlargement or additions to existing plant	29	159,000	--
Replace existing plant	17	60,100	--
No project required	72	273,738	--
Undetermined	5	6,100	6

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_4. Status of treatment works projects to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	35	--
Abatement ordered	0	--
Plans under preparation	4	--
Final plans approved	3	--
Construction awaiting financing	0	--
Under construction	7	--
Status undetermined	3	--

Table I4. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements	Remarks
Portales, N. Mex.	7,300	Additions	--
Texas:			
Abilene	40,000	Additions	--
Albany	2,000	Additions	Under contruction
Alvin	3,090	Additions	--
Aspermont	1,040	Additions	--
Bartlett	1,500	Replace plant	Planning improvements
Bay City	10,000	Replace plant	Under construction
Belton	5,000	Additions	--
Breckenridge	6,000	Additions	--
Bremond	600	Additions	--
Brenham	6,250	New plant	Under construction
Caldwell	1,500	Replace plant	Plans approved
Calvert	900	Replace plant	--
Cameron	4,000	Replace plant	--
Clyde	1,100	Additions	Preparing plans
College Station	3,500	Replace plant	--
Franklin	800	Replace plant	Planning improvements
Freeport	1,500	New plant	--
Gatesville	5,000	Additions	Under construction
Glenrose	750	Additions	--
Graham	6,000	Additions	--
Granbury	1,000	Additions	--
Granger	1,300	Replace plant	--
Groesbeck	1,800	Replace plant	--
Hempstead	1,800	Additions	--
Itasca	1,500	Replace plant	--
Marlin	5,200	Additions	Under construction
Mart	2,860	Additions	Preparing plans
Meridian	500	Additions	--
Merkel	1,500	Additions	--
Moody	900	Replace plant	--
Navasota	4,500	Additions	--
Palo Pinto	150	Replace plant	--
Ranger	4,000	Additions	--
Rogers	900	New plant	--
Rosebud	1,500	Additions	--
Giddings	1,200	Additions	Plans approved
Seymour	3,000	Replace plant	--
Slaton	4,000	Additions	--
Somerville	1,100	Additions	--
Stephenville	7,000	Replace plant	Plans approved
Sugarland	1,500	Additions	--
Taylor	7,500	Additions	Under construction
Temple	20,000	Replace plant	Under construction
Thorndale	900	New plant	Plans approved
Throcknorton	1,250	Replace plant	--
Valley Mills	1,000	Replace plant	--
Velasco	2,000	New plant	--
Waco	40,000	Additions	--
West	1,430	Additions	--
West Columbia	300	New plant	--
Whitney	830	Additions	--

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Note: Available industrial waste information is not in sufficient detail to permit determination of industrial needs.

COLORADO RIVER SUB-BASIN

The Colorado River rises in the border counties of western Texas and southeastern New Mexico, and flows about 900 miles in a south-southeasterly direction across the central part of Texas and discharges into the Gulf of Mexico. The sub-basin has an area of about 42,500 square miles and is slightly larger than Tennessee. The sub-basin is 100 to 150 miles wide in the upper and central parts and narrows to a corridor 10 to 15 miles wide along the lower 100 mile reach of the river. In its course through Texas, the Colorado River crosses three major physiographic divisions, namely, the High Plains, the North Central Plains and the Coastal Plains. About one fourth of the sub-basin, the upper 11,000 square miles, lies in the High Plains area, a high, flat arid region of low annual rainfall which contributes little to the flow of the river.

The mean annual rainfall over the sub-basin varies from about 15 inches in the extreme upper part to about 43 inches in the coastal region.

The average annual runoff for the sub-basin is 2,457,000 acre-feet with a maximum of 6,600,000 acre-feet and a minimum annual runoff of 472,000 acre-feet. The normal flow of the river varies between extreme limits. The gaging station at Austin, Tex., with a contributing area of over 38,000 square miles, has reported flows as low as 13 cubic feet per second and as high as 481,000 cubic feet per second. The flow of the river is affected by storage at Lake Travis and Lake Buchanan and other small reservoirs that have a combined capacity of 3,130,000 acre-feet. Controlled flow below the storage reservoirs is held at about 2,000 cubic feet per second. This is of considerable value from a pollution control standpoint, since it increases low flows and provides larger volumes of dilution water than naturally occur in the river for the greater part of the year.

Underground water sources are used extensively in the upper portion of the sub-basin for public water and irrigation supplies. Approximately 450,000 acres are irrigated at present in this area.

Numerous springs provide the Concho, San Saba and Llano Rivers with clear permanent waters flowing through well timbered country which attract fishermen, hunters, campers and tourists from a wide area. The main stem of the Colorado above the Concho drains arid regions of the sub-basin and has only limited recreational value. Below the Edwards Plateau, the reservoirs assure permanent water which is clear for many miles downstream and is intensely fished. The many reservoirs in the Sub-basin also provide excellent recreational facilities.

The limited industry of the sub-basin has been developed around petroleum and farm products and is quite uniformly distributed throughout the sub-basin with no concentration in any one area. There are no reported instances where industrial water use has been affected by pollution.

Thousands of oil wells are operating in the many oil fields of the sub-basin. Brine wastes from these wells are probably the greatest source of surface water pollution in the sub-basin with the exception of silt. The only reported damage by industrial waste pollution is the loss of waterfowl in playa lakes which was caused when these lakes were used by oil companies as slush pits.[4] The same source of information reported that nine miles of the Colorado River are polluted by industrial wastes from Austin, Tex. and by municipal wastes from Bastrop and Columbus, and that fishing in this area has been affected.

The silt load of the river is estimated to be more than 14 million tons or 9,000 acre-feet per year. About 4,100 acre-feet of this is retained in Buchanan Reservoir reducing the storage capacity by that volume each year. Silt from the Colorado River is reported to have all but destroyed some six to seven thousand acres of oyster reefs around Matagordo.

Over 98 percent of the 335,200 people served by sewers in the sub-basin were also served by sewage treatment facilities. Nineteen of the communities that had sewage treatment facilities applied the treatment plant effluent to land, discharged it to closed basins, or used it for irrigation. Such effluents from these communities seldom, if ever, reach running water and are not considered a factor in surface water pollution. Most of the sewered population was served by treatment facilities. Many of the sewage treatment plants required replacement or enlargement to adequately treat the volume of sewage. The condition of the streams was considered unsatisfactory immediately below 21 municipalities and at 19 of these a nuisance condition was reported. To correct and improve the stream conditions caused by municipal waste pollution required two new plants,

[4] Fish and Wildlife Service; see report: Information on Specific Problems of Water Pollution, Division of Water Pollution Control, January, 1949.

the replacement of six and additions to seven (according to July 1, 1950 data).

Only 13 industries in the sub-basin were known to be discharging wastes directly to the streams. Two of these treated their wastes, but the extent of this treatment or the amount of pollution originating at these industrial plants was not known. There are many industries which may contribute pollution to its waters. These include five refineries and petroleum processing plants, 13 chemical plants, five meat packing plants, 17 milk processing plants, four rendering plants, six cotton seed products plants and seven food processing plants including three which dry eggs.

Table A_5. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	0	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	46	335,223	Not applicable
Total	46	335,223	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_5. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	11**	Undetermined
Producing inorganic wastes	720***	Not applicable
Producing wastes of undetermined type	1	Undetermined
Total	723+	--

*Industries having separate outlets and discharging wastes directly to watercourse.

**Includes 9 plants also producing inorganic waste.

***Includes 710 individual oil wells.

+Total adjusted to correct for duplication noted in footnote marked thus**.

Note: There are approximately 5 refineries, 13 chemical plants, 5 meat packing plants, 17 milk processing plants, 4 rendering plants, 6 cotton seed products plants, 7 food processing plants and innumerable oil wells operating in the sub-basin for which no waste information is available at this time.

Table C_5.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	10	10	15,100
Secondary	34	34	314,337
No treatment	2	0	5,786

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary wastes directly to water course.

Table D_5. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and allied.....	2	1	—	1
Chemical and allied.....	1	--	--	1
Petroleum and coal.....	9	--	--	9
Oil production (Individual wells).....	710	--	--	710
Miscellaneous.....	1	1	0	0
Total	723**	2	--	721**

*Industries having separate outlets and discharging wastes directly to watercourse.
**Totals include 710 individual oil wells.
Note: There are approximately 60 industries and thousands of oil wells in the sub-basin for which no waste information is available at this time.

Table E_5. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	44	29	13	2	21	19	4
Industrial	2	--	1	1	--	--	2

Table F_5. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	--	--
1947	1	3,000	--	--
1948	5	40,200	--	--
1949	2	49,000	--	--

Table G_5. Requirements for municipal and industrial waste treatment plants

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	2**	5,794	--
Enlargement or additions to existing plant	7	134,200	--
Replace existing plant	6	36,200	--
No project required	[illegible]	158,729	--
Undetermined	[illegible]	300	723

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**In addition there are 2 communities with a population of 2,454 which do not have sewers at present for which both sewers and treatment plants are recommended. These project needs are listed in Table I_5.

Table H_5. Status of treatment works projects to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	9	--
Abatement ordered	0	--
Plans under preparation	2	--
Final plans approved	1	--
Construction awaiting financing	0	--
Under construction	5	--
Status undetermined	0	--

Table I5. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements	Remarks
Lovington, N. Mex.	2,000	Replace plant	Under construction
Tatum, N. Mex.	1,500	New plant	--
Texas:			
Austin	125,000	Additions	--
Bangs	1,200	Additions	--
Bastrop	1,400	New plant	--
Big Lake	1,000	Additions	--
Columbus	3,000	Replane plant	Plans approved
Eagle Lake	2,200	Replace plant	Under construction
Johnson City	950	New plant	--
Junction	1,200	Additions	Preparing plans
Mason	1,750	Additions	Under construction
Menard	3,000	Replace plant	--
Odessa	20,000	Replace plant	Under construction
San Saba	2,700	Additions	--
Santa Anna	1,350	Additions	Preparing plans
Snyder	6,000	Replace plant	Under construction
Wharton	4,390	New plant	--

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Note: Available industrial waste information is not in sufficient detail to permit determination of industrial needs.

GUADALUPE, LAVACA AND SAN ANTONIO RIVERS SUB-BASIN

This sub-basin which includes the water sheds of the Lavaca, Guadalupe, and San Antonio Rivers and several minor coastal streams is situated in southeastern Texas and extends from the Edwards Plateau to the Gulf of Mexico. It contains about 13,000 square miles, an area greater than Maryland and Delaware combined. The Guadalupe and San Antonio Rivers rising at an elevation of 2,300 feet in the Edwards Plateau are typical mountain streams until they cross the Balcones Escarpment which is the southern boundary of the plateau. From the Balcones Escarpment these rivers descend about 150 miles through rolling prairie country and the coastal plain to the Gulf. The Lavaca River in the eastern part of the sub-basin is a typical meandering coastal plain river.

The line of 25 inch annual rainfall crosses the upper part of the sub-basin but closer to the coast the rainfall increases so that the lower gulf area has an average rainfall of about 40 inches. At New Braunfels, the 39 year average annual precipitation was 30 inches with variations from a minimum of 13 inches to a maximum of 60 inches. The upper portion of the sub-basin has very intense rainfalls of moderate duration while the coastal area has intense rains of long duration.

Below the Edwards Plateau the rivers do not reflect these wide rainfall variations because they receive large constant volumes of spring water. The flow of the San Marcos and New Braunfels springs average 457 cubic feet per second--about 300 million gallons per day.

About half of the population is urban with most of the people living in or near San Antonio, the industrial, commercial, and transportation center of the region.

Ranching is the main farming activity in the upper section of the sub-basin, while cotton farming predominates in the lower portion. About 30 percent of the sub-basin area is used for crops and 50 percent for pasture. Irrigation is of vital importance to farming and has been practiced in the area since 1730.

Oil and gas are produced in several counties. Stone, gravel and material for cement and brick manufacture are the only other mineral resources actively worked

Industry is well dispersed throughout the sub-basin, using petroleum, cotton, wool and meat produced in the sub-basin as basic raw materials. Industrial wastes were not considered to be a problem except below the industrial center of San Antonio where damages due to pollution have been reported.

Because of the uniform river flow maintained by the large springs, dams for maintaining head without large storage reserve are practicable for power generation and several hydroelectric plants of this type have been installed in the sub-basin. In addition to power generation, the surface waters are used for recreation, irrigation, individual drinking water supplies, and industry. Most of the municipal water supplies are obtained from springs or from wells that draw upon the large underground reservoir supplying the springs.

All of the 40 municipalities which had public sewerage systems also had sewage treatment plants. About half of these were old plants which needed replacement or additional capacity. Inadequately treated wastes from these old plants are objectionable because the waters are extensively used for recreation, including swimming. The Texas State Health Department reports that nuisance conditions existed in the streams immediately below 21 of the municipalities of the sub-basin. Stream conditions at some of these locations can be corrected by proper operation of existing plants, but it was estimated on July 1, 1950 that major treatment plant additions or replacements were needed at 15 communities to correct the polluted conditions.

The industries located within the sub-basin which may produce injurious wastes include 28 milk products plants, 26 meat and poultry dressing plants, 18 food processing plants, 16 chemical plants, six textile plants, six refineries and petroleum processing plants, three breweries, three wineries and two tanneries.

Some of the industries in the sub-basin discharge their wastes to public sewer systems where they receive treatment in municipal treatment facilities. Of the 28 industries known to discharge wastes directly to the streams, three were reported to have treatment facilities. Limited information on industrial treatment facilities precluded any evaluation of the industrial waste treatment needs of the sub-basin.

The thousands of oil wells operating in the sub-basin produce large quantities of brine wastes with high salt content. Disposal methods practiced in the sub-basin keep most of this brine from the surface waters.

The city of Gonzales' water supply was harmfully affected by oil field wastes from the Luling area. Action by the water pollution control agencies resulted in the installation of brine disposal methods which have alleviated this condition.

It is reported that[5] fish and wildlife are seriously affected for ten miles of the Medina River and for 150 miles of the San Antonio River below San Antonio, Tex. Municipal and industrial wastes, chiefly from the city of San Antonio, are reported to be the cause of pollution. Treatment facilities under construction are expected to alleviate this condition. Texas State Department of Health reported that fish kills caused by plating wastes from military installations have occurred at times.

[5]Fish and Wildlife Service; see report; Information on Specific Problems of Water Pollution, Division of Water Pollution Control January, 1949.

Table A_6. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	0	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	40	529,875	Not applicable
Total	40	529,875	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_6. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	15	Undetermined.
Producing inorganic wastes	2	Not applicable
Producing wastes of undetermined type	11	Undetermined.
Total	28	--

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are approximately 28 milk products plants, 26 meat packing plants, 18 food processing plants, 16 chemical plants, 6 textile plants, 6 refineries, 3 breweries, 3 wineries, 2 tanneries and innumerable oil wells operating in the sub-basin for which no waste information is available at this time.

Table C_6. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	9	9	10,350
Secondary	31	31	519,525
No treatment	0	0	0

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

Table D_6. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and allied.....	11	1	5	5
Chemical and allied.....	4	0	4	0
Petroleum and coal.....	7	--	--	7
Fabricated metal.....	2	2	0	0
Miscellaneous.....	4	0	4	0
Total.....	28	3	13	12

*Industries having separate outlets and discharging wastes directly to watercourse.
Note: There are approximately 108 industries and innumerable oil wells in the sub-basin for which no waste information is available at this time.

Table E_6. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satis-factory	Unsatis-factory	Unde-termined	Satis-factory	Unsatis-factory	Unde-termined
Municipal	40	22	15	3	20	16	4
Industrial	3	--	--	3	--	--	3

Table F_6. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	2	13,200	--	--
1947	5	37,800	--	--
1948	2	4,800	--	--
1949	4	18,000	--	--

Table G_6. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	0	--	--
Enlargement or additions to existing plant	6	19,350	--
Replace existing plant	9	427,350	--
No project required	22	79,050	--
Undetermined	3	4,125	28

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_6. Status of treatment works projects to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	5	--
Abatement ordered	0	--
Plans under preparation	2	--
Final plans approved	1	--
Construction awaiting financing	0	--
Under construction	5	--
Status undetermined	2	--

Table I_6. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements	Remarks
Texas:			
Edna	2,800	Replace plant	Under construction
Floresville	3,000	Additions	--
Ganado	650	Additions	--
Goliad	800	Replace plant	--
Hallettsville	2,000	Replace plant	--
Kerrville	7,000	Replace plant	Under construction
Lockhart	4,000	Additions	Planning improvements
New Braunfels	9,000	Replace plant	Under construction
Nixon	1,500	Additions	Planning improvements
Port Lavaca	3,200	Replace plant	Under construction
San Antonio	400,000	Replace plant	Under construction
Seguin	9,000	Additions	Plans approved
Shiner	1,200	Additions	--
Waelder	700	Replace plant	--
Yorktown	1,850	Replace plant	--

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Note: Available industrial waste information is not in sufficient detail to permit determination of industrial needs.

NUECES RIVER SUB-BASIN

The Nueces River Sub-Basin lies entirely within southeastern Texas with its southern boundary roughly parallel to, and 10 to 35 miles from, the Rio Grande which is the international boundary between the United States and Mexico. The total area of the sub-basin is about 26,000 square miles, which approximates the combined areas of Maryland, Massachusetts and New Jersey. The Nueces River and its tributaries drain about 16,500 square miles of the sub-basin. Small streams, draining coastal lowlands, discharging into the Gulf, make up the balance of the area.

The Nueces River rises on the Edwards Plateau at an elevation of approximately 2,100 feet and flows over a long tortuous course for nearly 250 miles to Nueces Bay, which is an arm of the Gulf of Mexico. Within 40 miles of the plateau, the river drops to an elevation of about 1,000 feet in the region of the Balcones fault as it flows through canyons. An outcrop of the porous Carrizo sandstone, three to six miles in width lies below this fault.

Much of the water entering the Nueces River channel on the Edwards Plateau does not get past this fault and porous sandstone outcrop but is lost by seepage into underground channels. The United States Geological Survey estimates this loss at more than 150,000 acre-feet annually. One of the main problems of the sub-basin appears to be that of bringing the water from above this fault zone to irrigable lands below without excessive seepage losses or damaging depletion of underground reservoirs. Extensive irrigation, using ground water, is now practiced in the sub-basin below this zone. Heavy pumping has lowered the ground water table in some areas to the point where benefits from irrigation do not offset the increased pumpage costs. As a result, large acreages have been abandoned. Carrying the surface water past the fault and sandstone outcrop might prevent recharge of this ground water supply to the extent that further reduction of irrigation acreage would be necessary in the pumping areas.

The average annual rainfall is low but fairly uniform throughout the sub-basin, and is 22 inches at the headwaters and 25 inches at the Gulf. Year to year variations are extreme and range from a low of eight inches to a high of 45 inches. Violent local storms occur frequently. Accompanying rainfalls as high as 20 inches in three hours have been experienced.

The total annual discharge of the Nueces River at the Three Rivers, Tex. gage, which measures the flow from a drainage area of 15,600 square miles, has varied since 1916 from 54,000 acre-feet to 2,547,000 acre-feet. The average total annual discharge is over 716,000 acre-feet. The greatest deficiency of flow recorded since the Three Rivers gage was established occurred during the period October, 1916 to April, 1918. For two consecutive months, December 1917 and January 1918, no flow occurred in the river and for 12 consecutive months, February 1, 1917 to January 31, 1918 the total recorded flow was only 14,764 acre-feet. During periods of general rains, the Nueces River has continuous flow from the Edwards Plateau to Nueces Bay. During dry seasons, however, the river has alternate reaches of dry channel and active flow as a result of water loss into sub-channels and water gain from springs at other places. No accurate records of these losses and gains are available.

The Nueces Sub-Basin is sparsely settled, with a population of less than 13 persons per square mile. The total population is estimated to be about 330,000, with Corpus Christi, a deep water port, the largest city having a 1949 urban population estimated at 120,000. The population density, exclusive of Corpus Christi, is only eight per square mile.

About three million acres of the sub-basin are in the rocky hill country above or in divides just below the Balcones Fault, and are classified as woodland pasture. The remainder of the sub-basin is generally devoted to grazing, but the major portion consists of fertile tillable land that is well adapted to farming when irrigated. About 40,000 acres in the "Winter Garden" region were irrigated from wells in 1948. Only a few thousand acres are irrigated with surface water, because the natural stream flows are unreliable and storage reservoirs have not been constructed.

During recent years oil production has grown to major importance throughout the sub-basin and petroleum refineries are being established. Sulphur and rock asphalt are also produced and processed. Several industries have been developed throughout the sub-basin to process farm and ranch products.

The use of the surface waters of the sub-basin is largely limited to stock watering and some irrigation except in the Corpus Christi area where the public and industrial supplies are obtained from surface sources. The use of treated surface water has increased at Corpus Christi from 2.2 million gallons per

day in 1930 to 18.7 million gallons per day in 1946. In addition, about 9.0 million gallons per day of raw water are used by industry. The total water used in the Corpus Christi area for municipal and industrial supplies and for irrigation purposes amounts to about 40,000 acre-feet annually. This is only a small portion of the average annual river discharge of 716,381 acre-feet.

The Nueces River Conservation and Reclamation District holds a permit to appropriate 520,000 acre-feet of water, but its plans for construction of necessary works have not yet materialized.

Stream pollution in the sub-basin appeared to be confined to local areas where sewage or wastes were discharged into streams having little or no flow during dry seasons or where large volumes of waste were discharged to tidewaters. It has been reported[6] that Laguna Madre and a river in Kleberg County are polluted by industrial wastes at Kingsville, Tex. This condition has been corrected. Proper control of pollution is needed to improve fishing and oyster production.

Thirty-four municipalities had public sewerage systems and only two of these do not provide some type of waste treatment. Fifteen municipalities disposed of the sewage or treatment plant effluent by discharge to land or dry washes or by using it for irrigation, and six others discharged it to tidewater. The Texas State Health Department estimated that the construction of two new plants, the replacement of eight plants, and the enlargement of or additions to five others were needed to properly care for the sewage in the sub-basin.

Sub-basin industries which might produce wastes of a polluting character include 21 refineries, 17 milk products plants, 11 food processing plants and five chemical plants.

Of the 23 industries in the sub-basin which discharged industrial wastes directly to the surface waters, three provided some treatment for their wastes. Information on industrial wastes in the sub-basin does not permit an accurate determination of the treatment facilities needed.

Active oil fields in the sub-basin produce large volumes of brine wastes. Much of this is prevented from entering the surface waters by storage in evaporation ponds or injection into underground strata after treatment. Some brine wastes enter the streams and are reported to cause pollution of Mission River and Copano Bay.

Soil erosion is occurring at the relatively low rate of 0.09 acre foot per square mile annually from the 16,791 square mile drainage area of the Nueces River. While this is of little importance when compared to other western areas, it is of extreme importance at Lake Corpus Christi, the principal reservoir in the sub-basin.

From 1934 to 1948, siltation reduced its original storage capacity of 54,500 acre-feet by 27 per cent. The chief cause for the high rate of capacity loss is the large size of the drainage area as compared to the capacity of the reservoir. The original reservoir capacity was only 3.2 acre-feet per square mile of drainage area, which is one of the smallest ratios of storage to drainage area for an important water supply reservoir in the United States.

Table A7. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	0	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	34	177,157	Not applicable
Total	34	177,157	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

[6]Fish and Wildlife Service; see report: Information on Specific Problems of Water Pollution, Division of Water Pollution Control, January, 1949.

Table B_7. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	4	Undetermined
Producing inorganic wastes	--	Not applicable
Producing wastes of undetermined type	19	Undetermined
Total	23	--

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are approximately 21 refineries, 17 milk products plants, 11 food processing plants, 5 chemical plants, and innumerable oil wells, operating in the sub-basin for which no waste information is available at this time.

Table C_7.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	9	9	20,395
Secondary	23	23	153,880
No treatment	2	0	2,882

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

Table D_7. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and allied.....	3	2	1	0
Chemical and allied.....	3	1	2	0
Petroleum and coal.....	15	--	--	15
Primary metals.....	1	0	1	0
Miscellaneous.....	1	0	1	0
Total.....	23	3	5	15

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are approximately 50 industries and innumerable oil wells in the sub-basin for which no waste information is available at this time.

Table E_7. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	32	14	13	5	13	17	2
Industrial	3	--	--	3	--	--	3

Table F_7. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	--	--
1947	0	--	--	--
1948	5	21,300	--	--
1949	3	10,000	--	--

Table G_7. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	2	2,882	--
Enlargement or additions to existing plant	5	22,600	--
Replace existing plant	8	25,700	--
No project required	14	36,280	--
Undetermined	5	89,695	23

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Table H_7. Status of treatment works projects to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	7	--
Abatement ordered	0	--
Plans under preparation	14	--
Final plans approved	0	--
Construction awaiting financing	0	--
Under construction	4	--
Status undetermined	0	--

Table I. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements	Remarks
Texas:			
Aransas Pass	3,600	Additions	Planning improvements
Beeville	6,000	Replace plant	—
Devine	380	New plant	Under construction
Falfurrias	5,600	Additions	Planning improvements
George West	1,000	Replace plant	—
Kingsville	9,500	Additions	Planning improvements
Pleasanton	200	Replace plant	Preparing plans
Refugio	3,700	Replace plant	—
Robstown	6,000	Replace plant	Under construction
Rockport	2,100	Additions	Under construction
San Diego	1,800	Additions	—
Sinton	5,500	Replace plant	—
Taft	2,500	New plant	—
Three Rivers	2,000	Replace plant	Under construction
Woodsboro	1,300	Replace plant	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Note: Available industrial waste information is not in sufficient detail to permit determination of industrial needs.

PECOS RIVER SUB-BASIN

The Pecos River, which is one of the major tributaries of the Rio Grande, rises in the heavily forested mountains of north central New Mexico that are over 13,000 feet in elevation and flows generally southward for 755 miles to join the Rio Grande just east of the Big Bend at elevation 1,050. The Pecos Sub-Basin, with its area equally divided between New Mexico and Texas, contains some 35,000 square miles or an area roughly the size of the State of Virginia. About one fourth of the area lies in desiccating basins which contribute no water directly to the Pecos River.

The headwaters of the Pecos, and those of most of its tributaries, flow as typical high mountain streams through deeply cut canyons and narrow timbered valleys. Below Fort Summer, N. Mex., at River Mile 573, the Pecos breaks out into a wide alluvial valley with low hills and open grassland prairies. This country, in turn, gives way to arid rolling plains where greasewood and mesquite are the principal vegetation. Below Sheffield, Tex., at River Mile 90, the Pecos plunges into a deep box canyon to reach its confluence with the Rio Grande.

Rainfall over the Pecos Sub-Basin averages about 35 inches per year in the mountainous headwaters, 25 inches in the piedmont sections, and 13 inches over the vast plains which constitute, by far, the bulk of the watershed.

Temperatures vary with altitude, and usually range between 90°F. and -30°F. at the higher elevations and between 115°F. and 0°F. at lower elevations. Except for the winter snowstorms in the mountains, most precipitation over the sub-basin occurs as severe summer cloudbursts which may yield from two to four inches of rain within an hour.

During the 1850's, a number of stations of the old Butterfield Stages were located in the Pecos Valley. Shortly thereafter, the Loving-Goodnight Cattle Trail to Santa Fe was projected through the valley. Aside from a number of Army forts, established for the protection of travellers and a few settlers against both Indians and outlaws, there was little permanent development of the Pecos Valley until the coming of the railroads toward the close of the 19th century.

At the present time, the Pecos Sub-Basin is predominantly agricultural with large-scale beef cattle and sheep ranching on the extensive rangeland and with cotton, alfalfa, livestock, small grains, and some truck crops grown where irrigation is possible along the flood plains of the main stem and the permanently flowing tributaries. Large oil fields have been developed in the eastern New Mexico and the Texas portions of the sub-basin and oil refineries operate in some of the larger communities. Large potash workings, with attendant refining works, have been developed in southeastern New Mexico near Carlsbad.

The population density of the Pecos Sub-Basin is extremely low as there are but 34 incorporated communities, with an average of less than 4,000 inhabitants per community, in the entire sub-basin. The largest city of the sub-basin had a 1950 population estimated at 25,000.

The Pecos River is one of the more completely regulated rivers of the United States. Down to Alamogordo Dam at River Mile 586, the Pecos is subject to only minor control and the normal annual variations in flow at this point range between the approximate limits of 50 and 10,000 cubic feet per second. There are four major storage reservoirs on the main-stem Pecos. These reservoirs and the locations of their impounding dams are as follows: Alamogordo, 132,200 acre-feet, at River Mile 586; Lake McMillan, 38,660 acre-feet, at River Mile 403; Lake Avalon, 6,600 acre-feet, at River Mile 390; Red Bluff, 307,000 acre-feet, at River Mile 320. The combined storage capacity of these reservoirs is approximately twice the average annual discharge of the Pecos into the Red Bluff Reservoir. An annual river discharge at this point exceeding the combined storage capacity of the four reservoirs occurs with a frequency of but once in about five years. Under ordinary circumstances, virtually all water is stored in the reservoirs for release in strict accordance with downstream irrigation demands. It is obvious, therefore, that intermittent dry reaches develop at several points along the main-stem Pecos below Alamogordo Dam. The average annual runoff of the Pecos River near its mouth for the period 1924-46 was approximately 360,000 acre-feet with a maximum of 1,331,000 acre-feet and a minimum of 176,800 acre-feet. Use of the Pecos River water falls under the surveillance of the recently created Pecos River Compact Commission jointly administered by the States of Texas and New Mexico and the Federal government.

The Pecos River and tributaries serve as a community surface water supply for only East Las Vegas, West Las Vegas and Santa Rosa in N. Mex. But many unincorporated rural villages in the upper reaches of the watershed use the streams as the only source of supply. The river receives directly, the

treatment plant effluents from seven communities (combined estimated population served 52,500) as well as the untreated sewage from one community of about 600 sewered inhabitants.

The potential sources of industrial wastes in the Pecos Valley, principally the oil and potash refineries, utilize desiccating basins for the disposal of their wastes.

Table A_8. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	0	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	23	90,395	Not applicable
Total	23	90,395	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Sources of man-made pollution discharged to the flowing waters of the Pecos Sub-Basin are confined to scattered instances of overloaded sewage treatment plants, from which the effects are extremely localized.

On July 1, 1950 it was estimated that adequate treatment of municipal wastes in this sub-basin would require the construction of one new plant, the replacement of two existing plants and the enlargement of or additions to six others. Facilities for the correction and elimination of industrial waste pollution could not be ascertained with the information available.

Pollutants from natural sources, on the other hand, constitute problems of major significance. Soil erosion is severe and is constantly increasing maintenance costs of irrigation systems, and siltation is a growing menace to the storage reservoirs as well. Much of the original capacity of Lakes McMillian and Avalon already has been lost because of deposited silt. The lower Pecos also carries an enormous dissolved solids burden--estimated at 1.6 million tons annually at the mouth of the river--much of which is acquired in the reach between Carlsbad and the Texas border. The salt concentration of the lower Pecos has restricted the agricultural use of the main-stem water to irrigation of salt resistant crops.

Two instances of pollution damages to fish or waterfowl have been reported[7] for the Pecos River Sub-Basin as follows: (1) Inadequately treated domestic sewage from the city of Roswell, N. Mex. has affected fish and waterfowl in the Pecos River, and (2) the playa lakes in Texas are used by oil companies as slush pits and this is reported to have caused waterfowl losses.

Table I_8 indicates that a new sewage treatment plant for Roswell was under construction on July 1, 1950, in order to remedy the situation in this vicinity.

[7]Fish and Wildlife Service; see report; Information on Specific Problems of Water Pollution, Division of Water Pollution Control, January, 1949.

Table B_8. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	10**	Undetermined.
Producing inorganic wastes	6	Not applicable
Producing wastes of undetermined type	--	Undetermined.
Total	13/	--

*Industries having separate outlets and discharging wastes directly to watercourse.

**Includes 3 plants also producing inorganic wastes.

/Total adjusted to correct for duplication noted in footnote marked thus**.

Note: There are many industries and oil wells in the sub-basin for which there is no waste information available at this time.

Table C_8.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	5	5	19,900
Secondary	17	17	69,895
No treatment	1	0	600

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

Table D_8. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and allied.....	7	2	2	3
Petroleum and coal.....	2	2	0	0
Other mining.....	3	2	1	0
Miscellaneous.....	1	0	1	0
Total.....	13	6	4	3

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are many industries and innumerable oil wells in the sub-basin for which there is no waste information available at this time.

Table E_8. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	22	14	8	0	10	5	7
Industrial	6	6	0	0	6	0	0

Table F_8. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	--	--
1947	1	2,000	--	--
1948	0	--	--	--
1949	1	2,000	--	--

Table G_8. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	1**	600	--
Enlargement or additions to existing plant	6	36,595	--
Replace existing plant	2	25,500	--
No project required	14	27,700	6
Undetermined	0	--	7

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**In addition there are 3 communities with a population of 4,500 which do not have sewer systems at present for which both sewers and treatment plants are recommended. These projects are listed in Table I_8.

Table H_8. Status of treatment works projects to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	3	--
Abatement ordered	--	--
Plans under preparation	2	--
Final plans approved	2	--
Construction awaiting financing	0	--
Under construction	5	--
Status undetermined	0	--

Table Ig. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements	Remarks
Artesia, N. Mex.	7,000	Additions	Preparing plans
Carlsbad, N. Mex.	14,000	Additions	Preparing plans
Hagerman, N. Mex.	600	New plant	--
Jal, N. Mex.	1,200	New plant	Final plans approved
East Las Vegas, N. Mex.	5,500	Replace plant	Under construction
Loving, N. Mex.	1,400	New plant	Final plans approved
Roswell, N. Mex.	20,000	Replace plant	Under construction
Santa Rosa, N. Mex.	1,000	Additions	--
Ft. Stockton, Tex.	5,000	Additions	--
Kermit, Tex.	7,000	Additions	Under construction
McCamey, Tex.	2,595	Additions	Under construction
Rankin, Tex.	1,600	New plant	Under construction

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Note: Available industrial waste information is not in sufficient detail to permit determination of industrial needs.

UPPER RIO GRANDE SUB-BASIN

The Upper Rio Grande Sub-Basin, for the purpose of this report, is defined as that portion of the Rio Grande watershed between the headwaters and the confluence with the Pecos River. The sub-basin includes some 1,250 lineal miles of main-stem river, an area of approximately 81,560 square miles in the United States, and an unknown area within the Republic of Mexico which is outside the scope of this report. A substantial fraction of the area--approximating fifty percent--lies within desiccating basins that contribute no surface runoff.

The Rio Grande originates along the southern slopes of the Continental Divide in south central Colorado and flows generally southeast for 170 miles to the New Mexico line. The river flows southward 470 miles across New Mexico, breaking out of the high mountains and narrow valleys which characterize the headwater areas onto the broad arid plateau of central New Mexico. At the Texas line, the Rio Grande again swings eastward to enter deep and narrow canyons which extend for some 600 miles along the International Boundary to the junction of the Pecos.

Elevations within the sub-basin range from over 13,000 feet in the Sangre de Christo Mountains to the east in northern New Mexico to 1,050 feet at the confluence of the Rio Grande and the Pecos River.

Rainfall over the upper Rio Grande Sub-Basin varies markedly and more or less directly with the altitude. At Wolf Creek Pass, Col., in the extreme headwaters, the annual precipitation averages 29.8 inches whereas at Del Norte -- 30 airline miles distant and some 3,000 feet lower, --it averages but 8.3 inches. Except in the mountainous areas, the average rainfall over the sub-basin seldom exceeds ten inches a year in comparison with an average annual evaporation exceeding 60 inches over most of the sub-basin and reaching a maximum of 97 inches a year at Elephant Butte Dam. Most of the sustained runoff is provided by winter snows in the mountains for, in the arid parts of the sub-basin, river discharges decrease progressively downstream.

The mean annual discharge of the Rio Grande at Del Norte, Col., is 954 cubic feet per second; at the New Mexico border, 7.2 cubic feet per second; and out of Elephant Butte Reservoir, 1,198 cubic feet per second. The river and its major tributaries are under a considerable degree of control from a dozen storage dams that range in capacity from 15,600 acre-feet (Costilla) to 2,197,600 acre-feet (Elephant Butte). Reservoir discharges are restricted, within the limits of available storage capacity, to the downstream demands for irrigation and for power. The normal flow of virtually every tributary is diverted and used during the irrigation season as is the entire flow of the main-stem immediately above Elephant Butte Reservoir during critical periods.

All streams of the sub-basin, except those within the forested headwater reaches, are very turbid. Loose, poorly consolidated soil which is particularly susceptible to rapid erosion and arroyo formation prevails over most of the sub-basin. Overgrazing has destroyed much of the vegetative cover that formerly retained the soil. The Rio Grande carries approximately 12,800 tons of silt annually at the Colorado-New Mexico line. In New Mexico, the tributaries contribute an enormous silt burden that ruins the main-stem for recreational purposes and, in addition, creates a serious and costly problem of maintaining irrigation canals. It is estimated that approximately 37 million tons of sediment are annually brought into the main-stem Rio Grande by the New Mexico tributaries. Approximately 25 million tons are deposited within the stream bed itself and the remaining 12 million tons settle in the quiet waters of Elephant Butte Reservoir. The reservoir is estimated to have lost almost one-fifth of its original storage capacity because of siltation during the first 32 years of operation. Immediately below Elephant Butte Reservoir, the Rio Grande is quite clear, although it rapidly accumulates a second silt load which amounts to about 9.2 million tons annually at the junction with the Pecos.

Dissolved minerals also constitute important natural pollution of the Rio Grande. In general, the river water is soft, typical snowmelt in the mountainous headwaters, but it acquires a heavy burden of dissolved minerals from natural sources and from the repeated use of the water for irrigation in the arid lands downstream. At the lower end of the sub-basin, the dissolved solids reach an average of 1.3 million tons per year.

The Upper Rio Grande Sub-Basin originally was populated with cliff dwelling races and later by pueblo inhabitants who developed a very high order of civilization and, indeed, the only culture and architecture indigenous to North America. The first white man to enter the area was Cabeza de Vaca in 1536 during his 8-year, 10,000 mile walk from a ship wrecked on Galveston Island in the Gulf of Mexico to San Miguel de Culiacan on the Pacific Coast. DeVaca told Cortez--who had but recently plundered the empire of Montezuma--of fabulously wealthy cities that he had seen during his long travels. These tales led to a series of explorations during the middle 1500's

by Conquistadores from New Spain and, eventually, to the Spanish colonization of the Rio Grande Valley of New Mexico immediately after 1600. Two hundred years later, Anglo-Americans from the Atlantic seaboard poured into the Sub-Basin over the colorful Santa Fe trail and, after 1879, by railroad.

The Upper Rio Grande Sub-Basin still remains a sparsely settled area with a population density of about six inhabitants per square mile. The rural population is extremely sparse and largely restricted to scattered areas where water is available for the irrigation of farm lands or for stock watering. The urban population of the entire sub-basin is estimated at 408,500--of which 55 percent reside in the two cities of Albuquerque and El Paso.

The economy of the sub-basin rests predominately upon agriculture which is possible only under irrigation. Grazing, lumbering, and mining comprise the other principal industries of the sub-basin aside from the usual service industries of the cities and those associated with agriculture.

Recreation seekers are attracted to virtually every section of the sub-basin for diverse reasons. The mountainous areas draw summer residents, fishermen, hunters, campers, and winter sportsmen in great numbers. The Indian pueblos of the Rio Grande Valley in New Mexico--which have changed little since the days of the Conquistadores--constitute a mecca for both tourists and archaeologists. In Texas, the Big Bend country is sufficiently rugged and primitive to satisfy the most exacting wilderness seeker.

Surface waters of the Upper Rio Grande Sub-Basin were utilized for municipal purposes by four communities at a rate of approximately 3.5 million gallons per day for about 25,000 consumers. In addition, El Paso, Tex., supplied 107,000 consumers with five million gallons per day of combination surface and ground water. Water consumption within the sub-basin averaged about 120 gallons per day per consumer.

On July 1, 1950 flowing waters of the Upper Rio Grande Sub-Basin received the untreated wastes from five communities with an estimated combined sewered population of about 13,000; the primary treated wastes from four communities with a sewered population estimated at 113,000; and the wastes from six communities with a sewered population of 91,200 following secondary treatment. In addition, many communities discharged treated and untreated wastes into dry arroyos or desiccating basins which did not directly affect the water resources.

Very little data existed concerning the industrial wastes of the sub-basin. It is known that one large meat packing establishment in El Paso pipes untreated organic wastes to the Mexican side of the river for release. Also, various mines, refineries, and dairies are known to discharge wastes directly to watercourses, but the degree of treatment given, if any, and the overall effects of these wastes upon the receiving waters are not known. However, it is known that industrial wastes have resulted in tastes and odor problems and increased cost of treatment of the El Paso water supply.

There is no place in the Upper Rio Grande Sub-Basin where poor quality is known to restrict the present uses, of water. There are two areas from which it is reported that water of improved quality would be highly desirable. Irrigation demands upon the main-stem Rio Grande below the communities of Del Norte, Monte Vista, and Alamosa in Colorado leave very little water in the stream channel and greatly increase the probability that the untreated wastes from these sources will be diverted upon the croplands immediately downstream. Much the same situation develops in the main-stem below the City of El Paso where a serious pollution problem exists. Samples collected during 1947 by the International Boundary Commission nine miles below the El Paso sewer outfall revealed biochemical oxygen demands up to 80.5 ppm. and dissolved oxygen concentrations as low as 0.4 ppm.

Although man-made pollution does not appear to be a general problem in the Upper Rio Grande

Table A_9. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	0	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	35	269,607	Not applicable
Total	35	269,607	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, town; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_9. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	20**	Undetermined
Producing inorganic wastes	24	Not applicable
Producing wastes of undetermined type	11	Undetermined
Total	48+	--

*Industries having separate outlets and discharging wastes directly to watercourse.

**Includes 7 plants also producing inorganic wastes.

+Total adjusted to correct for duplication noted in footnote marked thus**.

Note: There are many industries and oil wells in the sub-basin for which there is no waste information available at this time.

Sub-Basin at the present time, irrigation water controls the economic stability of the entire sub-basin and constant vigilance must be maintained to prevent any pollution that might adversely affect this vital use.

To provide adequate treatment of sewage in this sub-basin it was estimated that it would be necessary to construct seven new sewage treatment plants, replace four and enlarge seven others.

Table C_9. Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	13	13	127,650
Secondary	12	12	124,000
No treatment	10	0	17,957

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

Table D_9. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and allied.....	17	4	5	8
Chemical and allied.....	1	--	--	1
Petroleum and coal.....	2	1	--	1
Fabricated metal.....	4	1	--	3
Other mining.....	20	1	4	15
Miscellaneous.....	4	--	3	1
Total.....	48	7	12	29

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are many industries and oil wells in the sub-basin for which there is no waste information available at this time.

Table E_9. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	25	14	11	0	10	3	12
Industrial	7	4	1	2	4	1	2

Table F_9. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	0	--	--	--
1947	0	--	--	--
1948	3	3,750	--	--
1949	5	15,500	--	--

Table G_9. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	7**	17,957	--
Enlargement or additions to existing plant	7	139,200	--
Replace existing plant	4	17,650	--
No project required	17	94,800	4
Undetermined	0	--	44

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**In addition there are 8 communities with a population of 11,136 which do not have sewer systems at present for which both sewers and treatment plants are recommended. These project needs are listed in Table I_9.

Table H_9. Status of treatment works projects to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	18	--
Abatement ordered	0	--
Plans under preparation	1	--
Final plans approved	1	--
Construction awaiting financing	0	--
Under construction	5	--
Status undetermined	4	--

Table I9. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements	Remarks
El Paso, Tex.	107,000	Additions	—
Ysleta, Tex.	3,000	Additions	Under construction
Alamogordo, N. Mex.	5,000	Replace plant	Under construction
Anthony, N. Mex.	1,800	New plant	—
Belen, N. Mex.	4,000	Additions	(Not urgent)
Carrizozo, N. Mex.	650	Replace plant	—
Central, N. Mex.	1,000	New plant	—
Grants, N. Mex.	1,000	New plant	—
Las Cruces, N. Mex.	9,000	Replace plant	—
Los Lunas, N. Mex.	500	Additions	—
Mesilla, N. Mex.	2,000	New plant	—
Mesilla Park, N. Mex.	2,200	New plant	—
Santa Fe, N. Mex.	18,000	Additions	Preparing plans
Silver City, N. Mex.	5,500	Additions	—
Socorro, N. Mex.	2,500	Replace plant	Preparing plans
State College	2,000	New plant	—
Taos, N. Mex.	1,200	Additions	(Not urgent)
Tularosa, N. Mex.	1,636	New plant	—
Alamosa, Colo.	5,330	New plant	—
Antonita, Colo.	1,200	New plant	Under construction
Center, Colo.	1,500	New plant	Under construction
Chama, Colo.	700	New plant	—
Creede, Colo.	600	New plant	—
Del Norte, Colo.	1,800	New plant	—
La Jara, Colo.	1,100	New plant	—
Monte Vista, Colo.	1,750	New plant	—

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Note: Available industrial waste information is not in sufficient detail to permit determination of industrial needs.

LOWER RIO GRANDE SUB-BASIN

The Lower Rio Grande Sub-Basin includes that portion of the valley extending between the confluence of the Pecos at River Mile 638 and the Gulf of Mexico. Most of the lower Rio Grande watershed lies within the Republic of Mexico and, therefore, beyond the scope of this report. The part of the sub-basin within the United States comprises a long narrow strip of approximately 14,500 square miles in area and exceeds 30 miles in width only in tne Devils River watershed in the upper end and again in the extreme lower end where the low flat Gulf Coastal Plain permits the extensive spread of Rio Grand water for irrigation. Throughout the entire length of the Lower Rio Grande Sub-Basin, the main stem of the river forms the International Boundary between the United States and Mexico. Jurisdiction over the main stem of the Rio Grande is a function of the International Boundary and Water Commission, United States and Mexico.

The 1924-47 normal annual discharge of the Rio Grande and the Pecos Rivers combined, which represents the flow entering the upper end of the sub-basin, was approximately 2,000,000 acre-feet. The upper Rio Grande contributed 83 percent and the Pecos 17 per cent. The normal annual discharge for the same period at River Mile 226 near Rio Grande City, recorded at a gage immediately about the extensive irrigation diversions of the lower valley, was approximately 4,900,000 acre-feet. The principal sources of surface water in the Lower Rio Grande Sub-Basin, and their proportionate contribution to the total discharge, are: Upper Rio Grande and Pecos (U.S.), 53 percent; Rio San Juan (Mexico), 12 percent; Devils River (U.S.), 11 percent; Rio Salado (Mexico), ten percent; minor Mexican tributaries, ten percent; and minor American tributaries four percent. There is no control over the Rio Grande water flows at the present time except for five wasteways, starting at River Mile 175, which serve to divert surplus flood waters directly to the Gulf of Mexico. Falcon Dam, with a planned storage capacity of 3,300,000 acre-feet, currently is under construction at River Mile 290 by the International Boundary and Water Commission. When completed, it will alter materially the downstream water regimen in the interests of irrigation and municipal water supplies.

The Rio Grande carries a very heavy silt burden and a relatively heavy concentration of dissolved solids throughout the entire sub-basin. During the period 1943-47, the river carried a mean annual silt load over 9,350,000 tons at its entrance into the sub-basin, 99 percent of which came from the Upper Rio Grande. At River Mile 250, the silt load had increased to approximately 10,806,000 tons per year. At the upper end of the sub-basin during the period 1935-47, the Rio Grande carried a mean annual dissolved solids burden of 2,558,000 tons, of which 1,601,000 tons were contributed by the Pecos River. Dilution by relatively salt-free tributaries downstream subsequently reduced the concentration of dissolved solids. Apparently, neither silt nor dissolved solids is present in sufficient concentration to adversely affect current uses of the Rio Grande water.

The Lower Rio Grande Sub-Basin is composed of two radically different sections. From the mouth of the Pecos at River Mile 638 downstream to approximately River Mile 175, the Rio Grande tranverses a semi-arid, rolling to broken terrain covered with some prairie grasses but mostly with typical dry brush country vegetation except for the narrow alluvial flood lands closely paralleling the rivers where irrigation permits intensive cultivation of cotton and truck crops. These limited areas under irrigation total only about 56,000 acres in the entire upper portion of the sub-basin. Large-scale beef cattle, sheep, and some goat ranching comprise the principal, and virtually the only, industry of the uplands. Rainfall over this portion of the sub-basin averages about 20 inches per year. Normal mean seasonal temperatures range between 50 F. and 90 F. There are very few industries in the upper part of the Lower Rio Grande Sub-Basin and water-borne wastes from the American side are confined to the treatment plant effluents from the cities of Del Rio, Eagle Pass and Laredo. There have been no reports of any serious degradation in river water quality from these sources.

Between approximately River Mile 175 and the Gulf of Mexico, the Rio Grande traverses the broad flat Coastal Plain in what is commonly called the "Magic Valley" and which is completely unlike the upper portion of the sub-basin. Over this area, widespread irrigation in a semi-tropical climate has produced an amazing agricultural development. Precipitation here averages slightly less than 30 inches a year with normal seasonal temperatures ranging between 60 F. and 85 F.

The "Magic Valley", with about 600,000 acres currently under irrigation--or less than two percent of the total cropland of Texas--leads the entire State in the production of cot-

ton, citrus fruits, and many vegetable crops. The area under irrigation will be assured a firm water supply following completion of Falcon Dam. In addition to the cultivated lands, the "Magic Valley" has more than 70 municipalities and an oil field which, in estimated reserves, is second only to "the biggest of them all", the East Texas Oil Field. The largest industry, by far, within the "Magic Valley" is fruit and vegetable processing. One city, McAllen, Texas with a population of but 17,000 reputedly is the largest combined fruit and vegetable canning center in the Southwest. Approximately 100 canneries and quickfreezing establishments operate on a year round basis. Other major industries of the area include oil refineries, a 45-million dollar chemical plant for converting natural gas into liquid petroleum and by-products, a candy factory with a considerable daily production of "bubble gum" and peppermint stick candy, and castor and cotton seed oil production. A fleet of approximately 200 vessels, that operate from the mouth of the river, supply a large fish and shellfish packing and processing industry.

More than 100 industries are operating in the sub-basin, but industrial waste information was available for only nine of them. Data on these wastes were unavailable, so treatment facilities required to properly dispose of the waste from these nine industrial plants could not be estimated.

Within the "Magic Valley", only Brownville and San Juan (combined population estimated at 41,000) discharged urban wastes, following treatment into the Rio Grande. All others, of the many communities in this densely populated area discharged wastes into the Arroyo Colorado, a natural drainage basin paralleling the Rio Grande to the north but emptying independently into the Gulf of Mexico. The Arroyo Colorado has been enlarged to serve the multiple purposes of a wasteway for surplus Rio Grande water, a drainage canal for irrigated lands, and a sewer. The Arroyo Colorado is reported at times to be heavily overloaded with domestic sewage and wastes from the many fruit and vegetable processing industries of the area. The enclosing terrain is such, however, that undesirable conditions in the Arroyo Colorado in no way affect quality of the Rio Grande water. A court injunction is currently in effect against one of the valley cities to reduce pollution of the Llano Grande which drains to the Arroyo Colorado.

This valley is the site of a study being conducted by the Texas State Department of Health to determine a satisfactory and economical process for treating citrus canning wastes.

The Texas State Department of Health has recommended the replacement of five sewage treatment plants and the enlargement of seven others as necessary to provide for adequate treatment of sewage in this sub-basin.

Table A_{10}. Sources of pollution, municipal

Municipalities*	Sources of pollution (in number of municipalities)	Population served by sewerage system	Amount of pollution discharged to watercourse (in terms of equivalent number of people)**
Having data on pollution load discharged to watercourse	0	--	--
Having population data available (Data on pollution load to watercourse incomplete or not available)	23	157,090	Not applicable
Total	23	157,090	--

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

**Includes industrial wastes discharged into municipal sewerage systems.

Table B_{10}. Sources of pollution, industrial*

Industries	Sources of pollution (in number of plants)	Amount of pollution discharged to watercourse (in terms of equivalent number of people)
Producing organic wastes	--	--
Producing organic wastes	1	Undetermined
Producing inorganic wastes	--	Not applicable
Producing wastes of undetermined type	8	Undetermined
Total	9	--

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are approximately 100 industries operating in the sub-basin for which no industrial waste information is available at this time.

Table C_{10}.
Existing treatment facilities, municipal

Degree of treatment provided	Number		Population served
	Municipalities*	Plants	
Primary	8	8	56,000
Secondary	15	15	101,090
No treatment	0	0	0

*Includes incorporated or unincorporated municipalities; other legal bodies as sanitary districts, counties, towns; significant institutions, resorts, recreational centers, or other population centers, and industries discharging sanitary sewage wastes directly to watercourse.

Table D_{10}. Existing treatment facilities, industrial*

Type industry	Number of plants	Number of industrial plants having:		
		Treatment facilities	No treatment facilities	Undetermined facilities
Food and allied.....	1	1	0	0
Chemical and allied.....	1	0	1	0
Petroleum and coal.....	7	--	2	5
Total.....	9	1	3	5

*Industries having separate outlets and discharging wastes directly to watercourse.

Note: There are approximately 100 industries and several oil wells operating in the sub-basin for which no waste information is available at this time.

Table E_{10}. Adequacy of existing treatment facilities

Existing treatment facilities	Number	Adequacy with relation to:					
		Capacity			Operation		
		Satisfactory	Unsatisfactory	Undetermined	Satisfactory	Unsatisfactory	Undetermined
Municipal	23	11	12	0	9	12	2
Industrial	1	--	--	1	--	--	1

Table F_{10}. Progress in pollution abatement

Year	Municipal		Industrial	
	Plants completed	Design population	Plants completed	Amount of waste treated (in terms of equivalent number of people)
1946	1	10,000	--	--
1947	2	28,000	--	--
1948	0	--	--	--
1949	3	45,000	--	--

Table G_{10}. Requirements for municipal and industrial waste treatment plants*

Requirements	Municipal		Industrial
	Number	Population served by facilities	Number
New plant	0**	--	--
Enlargement or additions to existing plant	7	78,730	--
Replace existing plant	5	22,500	--
No project required	11	55,860	--
Undetermined	0	--	9

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

**There is one municipality requiring a new treatment plant. Because this plant is under construction, it has not been listed.

Table H_{10}. Status of treatment works projects to abate pollution, July 1, 1950

Status of project	Number	
	Municipal	Industrial
No formal action	7	--
Abatement ordered	--	--
Plans under preparation	1	--
Final plans approved	--	--
Construction awaiting financing	--	--
Under construction	4	--
Status undetermined	--	--

Table I_{10}. Project list - municipalities and industries requiring improvements for abatement of pollution*, July 1, 1950

Name	Population served	Project requirements	Remarks
Texas:			
Bracketville	2,000	Replacement	Under construction
Brownsville	25,000	Additions	--
Del Rio	3,230	Additions	Under construction
Donna	4,500	Replace plant	Under construction
Edcouch	500	Additions	--
Harlingen	25,000	Additions	--
LaFeria	1,000	Replace plant	--
Laredo	15,000	Additions	Planning improvements
Mercedes	10,000	Replace plant	--
Raymondville	5,000	Replace plant	--
San Juan	2,000	Additions	Under construction
Weslaco	8,000	Additions	--

*The needs set forth in this table are based on presently available information. However, future studies and evaluations may result in some changes in these needs.

Note: Available industrial waste information is not in sufficient detail to permit determination of industrial needs.